Bell Telephone MAGAZINE

Finding Out What People Think of Us • ARTHUR H. RICHARDSON and C. THEODORE SMITH

Three-Minute Furloughs • HAROLD A. WHITE

Bell Laboratories' Rôle in Victory • PHILIP C. JONES

Western Electric Experts with the Armed Forces • J. STEDMAN WARD

Bell Telephone Magazine

Spring 1946

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"The ideal and aim of the American Telephone and Telegraph Company and its Associated Companies is a telephone service for the nation, free, so far as humanly possible, from imperfections, errors, or delays, and enabling anyone anywhere to pick up a telephone and talk to anyone else anywhere else, clearly, quickly and at a reasonable cost."

A Medium of Suggestion & a Record of Progress

Published for the supervisory forces of the Bell System by the Information Department of AMERICAN TELEPHONE AND TELEGRAPH CO., *195 Broadway, New York 7, N. Y.*
WALTER S. GIFFORD, *Pres.*; CARROLL O. BICKELHAUPT, *Sec.*; DONALD R. BELCHER, *Treas.*

Who's Who & What's What

in This Issue

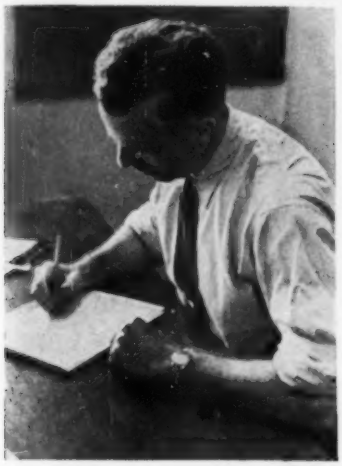
GALLUP POLLS, *Fortune* surveys, and similar phenomena of the current American scene were not so commonplace back in 1929, when A. T. & T. Vice President Arthur W. Page asked Seymour L. Andrew, then Chief Statistician and now retired, to undertake the study of public opinion survey methods and their applicability to the telephone business. As a result of that request, ARTHUR H. RICHARDSON and C. THEODORE SMITH were assigned to carry on the development of the work in this field. They have been at it ever since: asking questions and analyzing the answers, broadening the field and developing and refining methods, increasing the accuracy and the significance of the facts they uncover—and helping the Associated Companies of the Bell System to do more and more of the same. The article beginning on page 5 is the first general description of this System activity to be published.

Mr. Richardson started in the Statistical Division in 1919, and for a decade devoted himself to methods of statistical analysis and presentation and was active in the organization and development of statistical work in the Associated Companies. As General Research Statistician, his activities, in addition to public opinion research, cover the field of opinion surveys as applied to employee relations and to the telephone market. Mr. Smith, who has worked closely with Mr. Richardson since he joined the Statistical Division in 1929, contributed "Exhibiting Telephone Progress at the World's Fair" to the BELL TELEPHONE QUARTERLY for January 1934.

Fact-uncoverers: ARTHUR H. RICHARDSON (right) and C. THEODORE SMITH

Back from a "rather active assignment": Long-Liner HAROLD WHITE

NO EXTENSIVE RESEARCH is necessary to find out what members of the Armed Forces who were—or are—overseas think of the provision of telephone service which enables them to talk with family or friends even from the other side of the world. It is the final follow-through of the service which the Bell System has strained to make available at camps, hospitals, debarkation centers —wherever Service men and women have



Science Editor, editing: PHILIP C. JONES

needed it. And the literally hundreds of thousands of calls which have been placed to this country from the European and Pacific Theaters are all the evidence needed about GI public opinion of the service.

Overseas telephony is provided by A. T. & T.'s Long Lines Department, which HAROLD A. WHITE joined as a technical student in 1928. Various assignments preceded his appointment in 1939 as district plant superintendent at Washington, D. C. "Due to the war," he notes, "this was a rather active assignment"—which might be taken as an understatement. The war over, he was brought back to Long Lines headquarters at New York, where for a year he has been staff supervisor of overseas services.

OF BELL LABORATORIES' diverse and effective assistance to the Armed Forces of this nation and its allies in World War II, about half was devoted to the development of radar. But its resources and personnel were called on for help in other fields also, and some of its other contributions were not only invaluable but unique. A few of them PHILIP C. JONES describes in the article beginning on page 37. Mr. Jones is Science Editor of *Bell Laboratories Record*, and has thus been able to draw freely upon material which he had written or edited for that publication. Before joining the technical staff of the Laboratories in 1927, he had had 15 years' engineering experience in this country and in South America.

MEMBERS OF the Armed Forces responsible for the maintenance and operation of radar and other electronic devices, in all branches of the Service and in all parts of the world, found Western Electric's Field Engineering Force a supporting host in time of need. J. STEDMAN WARD tells some of the facts and some of the happenings which made it so; and he knows about such things. For it was he who formed the F. E. F. and guided its destiny for five years.

Mr. Ward was employed by Western Electric in its Engineering Department (later to become Bell Laboratories) in 1919. His early experiences included work with ship-to-shore radio telephone service and with Western Electric radio broadcasting equipment. When "talking movies" became a reality, he helped to introduce the Western Electric system of sound motion picture equipment; and he became director of operations for Electrical Research Products Incorporated in charge of its field installations and service organization. Now, with the F. E. F. on a peacetime scale, he becomes coördinator of personnel and training in Western's Installation Department.

Welcome to Hawaii: J. STEDMAN WARD (right) being greeted in 1944 by Navy Captain A. L. Becker, then Electronics Officer at Pearl Harbor

A FAMILIAR EMBLEM in an unfamiliar setting. Note the words "Frankfurt, Germany," at the bottom of the sign. At the request of the Army, the Bell System reestablished and operates the overseas telephone circuits between the United States and the U. S. occupation zone in Germany—the only area abroad from which it operates. See "Three-Minute Furloughs," page 20

Carefully Conducted Attitude Surveys, Using Scientific Methods, Reveal Useful Facts about Customers' Opinions of Telephone Service and the Telephone Company

Finding Out What People Think of Us

Arthur H. Richardson and C. Theodore Smith

THE BELL SYSTEM now handles about thirty *billion* telephone calls a year. It sends out millions of bills; its installers and repairmen make millions of visits to customers' premises; and there are innumerable other contacts between the public and the System's operating companies. Add them all up, and you will have some idea of the number of occasions which the public has for forming impressions of telephone service and of the companies which furnish it.

For many years the Bell System has been using various ways of finding out what those impressions are. The continuous service-measurement plans of the departments, and the many contacts which employees have with users of the service, give a fairly good indication of how successful each Associated Company is in giving people the kind of service they want. And voluntary comments of customers, in person, over the telephone, by letter, supplement this information.

But there are many millions of telephone users whom the company seldom or never sees or hears from; and the great majority of people do not indicate what they think unless they are asked. To get the views of both the articulate and the inarticulate, and to cover subjects on which they are not likely to volunteer an expression of opinion, the System is making increasing use of opinion surveys. In these studies it finds out what people are thinking by going directly to them with questions; and by carefully selecting a relatively small sample of customers for questioning, a reliable indication can be obtained of the opinions held by the whole group under study.

The first organized customer opin-

ion survey in the Bell System was made in Detroit toward the end of 1925. It was conducted by J. D. Houser and Associates, one of the pioneer firms engaged in measuring attitudes. Many of the methods employed, which have since had widespread use in other Bell System studies, were developed by Dr. Raymond Franzen, who was then a member of the Houser organization and with whom the A. T. & T. Co. has since maintained a consulting arrangement.

In 1929, subsequent to a Houser survey of the effectiveness of American Telephone and Telegraph Company advertising, made in Pittsburgh, a unit was set up in the Chief Statistician's Division of A. T. & T. to determine possible applications of opinion survey techniques to problems in the Bell System. Since that time this unit has been engaged in developing methods and in assisting the Associated Companies to conduct surveys, and has prepared numerous reports based on the findings of studies made in conjunction with the companies.

During the twenty years that opinion surveys have been made in the Bell System, the views of more than five hundred thousand people (representative of many millions) have been obtained on many different subjects in hundreds of studies carried out in many different cities, towns, and rural communities over the country. For the most part, these studies have been conducted by the telephone companies themselves, as early experience indicated that it was possible for company representatives to obtain from the public full and frank expressions of opinion regarding telephone service and other phases of the business.

The opinion surveys have varied widely in scope and purpose; but all have aimed to contribute facts about customer opinions needed to arrive at sound solutions of problems in which attitudes of our customers or of the public generally were involved. For example, surveys have been useful:

In finding out which specific aspects of telephone service the user feels most need improvement.

In measuring customer satisfaction with service in small offices where service measurements are not normally made.

In determining telephone service requirements of people living in rural areas.

In determining marketing habits of housewives, as a basis for promoting use of the telephone for shopping.

In determining the needs, attitudes, and expectations of applicants who are waiting for telephone service.

In deciding what improvements in pay station facilities are most desired by users.

In considering possible revisions of telephone exchange boundaries.

In revising the form of telephone bills to increase their clarity.

In determining how telephone directories may be improved to facilitate reference and to increase use.

In determining the most effective placement of advertising in daily newspapers.

In determining the size of audience of telephone company radio programs.

In determining the effectiveness of various campaigns to promote toll usage.

IT WAS RECOGNIZED from the start of the activity that the study of opinions and attitudes was not a simple undertaking. In dealing with intangibles of this character, it was apparent that a good deal of experimenting with methods would have to be done if sound conclusions were to be reached. The measurement of public attitude was a new field, and at the outset little guidance could be obtained from outside sources. So the early studies made in the Bell System were looked on as primarily experimental, and procedures were thoroughly tested to determine those which seemed to give the most reliable results. In this experimental work the Associated Companies cooperated, and they have contributed materially to the development of methods and procedures.

At the beginning of the survey activity it was feared that there might be some unfavorable reaction on the part of our customers and the public generally. However, the general experience has been that the public does not object to being questioned, but, on the contrary, is very willing to answer questions about telephone service and the telephone company. Apparently, people appreciate the interest shown by the company in soliciting their views, and it is now generally recognized that the survey activity has a definite customer relations value.

CONDUCTING a customer opinion survey by means of telephone interviews

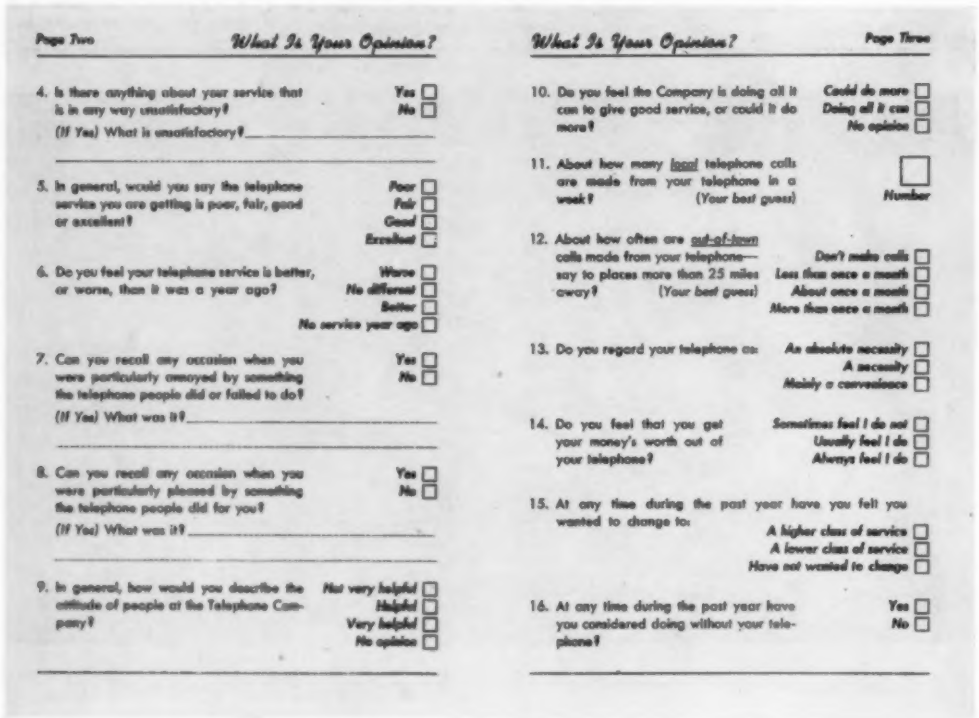
It is important, of course, that the procedures followed in obtaining the necessary information from people should not annoy or irritate them; for, in addition to the effect on customer relations, this could lead to

inaccuracies in survey results. To avoid any possibility of such reaction, special care should be exercised in planning and conducting each study.

How Surveys Are Made

IN SETTING UP an opinion survey, the first essential, as in the case of most other scientific inquiries, is a clear-cut definition of objectives: specifically, what the problem is, what information is needed in connection with the problem, and along what lines the inquiry should be directed to obtain results which will have practical application. The actual steps followed will vary from study to study, but there are certain fundamental procedures common to most opinion surveys. These include:

Developing the Questionnaire
Selecting the Sample
Getting the Information
Analyzing the Results



Page Two — *What Is Your Opinion?*

4. Is there anything about your service that is in any way unsatisfactory? — Yes ☐ No ☐
(If Yes) What is unsatisfactory? _____

5. In general, would you say the telephone service you are getting is poor, fair, good or excellent? — Poor ☐ Fair ☐ Good ☐ Excellent ☐

6. Do you feel your telephone service is better, or worse, than it was a year ago? — Worse ☐ No different ☐ Better ☐ No service year ago ☐

7. Can you recall any occasion when you were particularly annoyed by something the telephone people did or failed to do? — Yes ☐ No ☐
(If Yes) What was it? _____

8. Can you recall any occasion when you were particularly pleased by something the telephone people did for you? — Yes ☐ No ☐
(If Yes) What was it? _____

9. In general, how would you describe the attitude of people at the Telephone Company? — Not very helpful ☐ Helpful ☐ Very helpful ☐ No opinion ☐

What Is Your Opinion? — Page Three

10. Do you feel the Company is doing all it can to give good service, or could it do more? — Could do more ☐ Doing all it can ☐ No opinion ☐

11. About how many local telephone calls are made from your telephone in a week? (Your best guess) — ☐ Number

12. About how often are out-of-town calls made from your telephone—say to places more than 25 miles away? (Your best guess) — Don't make calls ☐ Less than once a month ☐ About once a month ☐ More than once a month ☐

13. Do you regard your telephone as: — An absolute necessity ☐ A necessity ☐ Mainly a convenience ☐

14. Do you feel that you get your money's worth out of your telephone? — Sometimes feel I do not ☐ Usually feel I do ☐ Always feel I do ☐

15. At any time during the past year have you felt you wanted to change to: — A higher class of service ☐ A lower class of service ☐ Have not wanted to change ☐

16. At any time during the past year have you considered doing without your telephone? — Yes ☐ No ☐

WHAT IS a telephone company questionnaire like? Here are two pages from one which was used in a nation-wide survey of customer opinion

Developing the Questionnaire

MOST BELL SYSTEM attitude surveys are conducted on a questionnaire basis, in which each individual in the sample is asked a prepared list of questions. This assures that all pertinent aspects of a subject will be

covered with each person. Moreover, definite response categories are provided for most questions, which makes possible the statistical analysis of results. This does not prevent free expression of opinion, however, and space is always provided on questionnaires for customer comments.

There are, of course, certain general principles which should be observed, such as avoidance of words which may mean different things to different people, and of leading questions and of questions which might cause people to "cover up."

It is customary on a new project to

USE OF THE TELEPHONE
ABOUT HOW FAR FROM YOUR PLACE IS THE NEAREST TELEPHONE YOU CAN USE IF YOU HAVE TO?
Less than ¼ mile
None available
¼ to ½ mile
½ to 1 mile
Over 1 mile
HERE TO
THERE
ABOUT HOW MANY CALLS DOES YOUR FAMILY (INCLUDING YOURSELF) MAKE IN A MONTH?
About ____ calls per month
(Write in number)
Don't make calls
FOR WHAT PURPOSES HAVE YOU OR OTHER MEMBERS OF YOUR FAMILY USED THE TELEPHONE MOST DURING THE PAST YEAR?
(Please write in)
Don't make calls
CAN PEOPLE GET IN TOUCH WITH YOU BY TELEPHONE WHEN THEY HAVE TO?
Yes
No
(If yes)
ABOUT HOW OFTEN DO YOU OR SOME MEMBER OF YOUR FAMILY GET CALLED TO THE TELEPHONE?
About ____ times per month
(Write in number)
Don't get calls

A NOT-TOO-SERIOUS ATMOSPHERE helps to create interest in answering questions: facing pages from a questionnaire to rural non-subscribers

The preparation of the questionnaire is one of the most exacting phases of the whole survey activity. There are few definite rules which can be laid down in framing the questions—for this depends on judgment, and on experience as to what has proved productive and what has not. conduct a small-scale "pilot" study before proceeding with the survey proper. This provides an opportunity to experiment with introductions, question wordings, order of questions, and any special or unusual procedures which it may be desirable to try out.

Selecting the Sample

ALMOST ALL opinion studies are conducted on a sampling basis; that is, a cross-section is selected in such a way as to represent in miniature the total group of people whose views are desired. But to secure an accurate cross-section picture, the procedure used in selecting the individuals who are to comprise the sample is of first importance.

Methods of sample selection vary, depending on such factors as the characteristics of the group to be studied and on the availability of information regarding this group. In telephone company surveys of subscribers, sampling is greatly simplified because the names and addresses of all of our customers are listed in telephone directories and elsewhere in company records. These lists provide an excellent basis for sampling, since they make it possible to use a "random" method of selection.

To illustrate one of the simpler applications of this procedure: suppose it were desired to conduct a survey by telephone in which some 500 residence customers were to be chosen as a sample of all residence subscribers in some particular city or town. The telephone directory for the community would be divided into 500 equal sections. Interviewers might be instructed to obtain an interview with the first available residence subscriber in each of the 500 sections.

If the study were to be made on the basis of visits to the premises, a smaller number of so-called "interviewing spots" might be selected at

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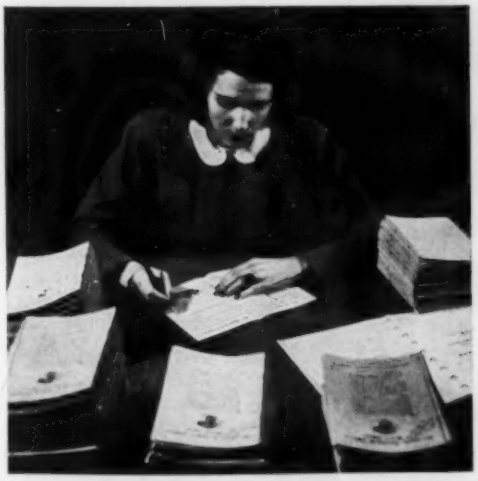
AT THE LEFT are the covers of some questionnaires used in attitude surveys

random and a group of interviews obtained in each, thus reducing the amount of travel involved.

While the random method of sample selection might appear haphazard and unorganized, actually it follows certain fundamental mathematical laws. The reliability of this method in telephone company surveys is evident when comparisons are made of the known characteristics of the whole group with similar distributions for the sample.

As to the size of the sample necessary for a given study, a number of factors are controlling. All samples are subject to a certain amount of "error"; that is, results will differ somewhat from those that would have been obtained had the total group been covered. Assuming that the sample has been properly selected, the extent of the error depends on the size of the sample: the greater the accuracy desired, the larger the sample must be. Also, of course, the greater the number of sub-group comparisons to be made, the larger the sample must be.

It is surprising to many that the actual size of the total group from which a cross-section is to be taken has relatively little to do with the number of interviews required. Of more importance is the degree of homogeneity in the group being studied. Where there is little uniformity of opinion in the group, more interviews are necessary to achieve a



AT THE RIGHT are shown steps in tabulating attitude survey results. Top to bottom: "editing" and "coding" questionnaires; punching responses to questions on tabulating cards; sorting punched cards and counting responses

given degree of accuracy than where people's opinions tend to be similar.

Getting the Information

THERE ARE various ways of obtaining attitude information from the public. Each has its advantages and disadvantages, and the procedure used for any specific survey would be the one which would provide the most reliable and useful results in connection with the problem at hand.

Face-to-Face Interviews have been used in conducting many Bell System surveys. While this method is relatively time-consuming, it has particular advantages where a new problem is being explored, where many questions are to be asked, where the questions are on subjects unfamiliar to the customer, or where it is necessary that the questions be answered in definite order.

Face-to-face interviews must be made, of course, where observation of the premises is necessary to get data on economic status or to observe telephone facilities; or where, as a part of an interview, it is desired to show advertisements or check lists, or to ask the customer to perform some operation such as to look up telephone numbers or to dial a call.

One of the more difficult aspects of the face-to-face interview is the proper recording of answers and comments without interfering with the conduct of the interview. No attempt is made to conceal the questionnaire form, and responses and comments are recorded as the interview proceeds. Experience has been that people not only do not mind having their answers written down but, as a matter of fact, seem to feel that it is the logical thing for the interviewer to do.

Telephone Interviews have been used extensively, particularly for studies of attitude toward telephone service. Customers seem to feel it is appropriate for the company to use the telephone in interviewing them about their service. Telephone interviews are less time-consuming and less expensive than premise interviews, and can be supervised much more closely. While the telephone interview has many of the advantages of the premise interview, it must be relatively short and the questions must be of a type which people can answer readily.

In surveys involving either face-to-face or telephone interviewing, proper handling of the interview is of crucial importance and requires training, skill, and experience. In the introduction to the interview, the purpose of the survey is explained to the person, and the company's interest in getting a frank expression of opinion is emphasized. Every precaution is taken to insure that answers will not be influenced in any way; naturally, interviewers refrain from expressing their own opinions, and questions raised by the person being interviewed are usually deferred for answer until the end of the interview.

IN CONTRAST to interviews where questionnaires are filled out by an interviewer, there are other procedures whereby customers fill out the questionnaires themselves. For example, questionnaires have been left at pay stations, and have been given out at business offices, at telephone company "open houses," at telephone exhibits and demonstrations. How-

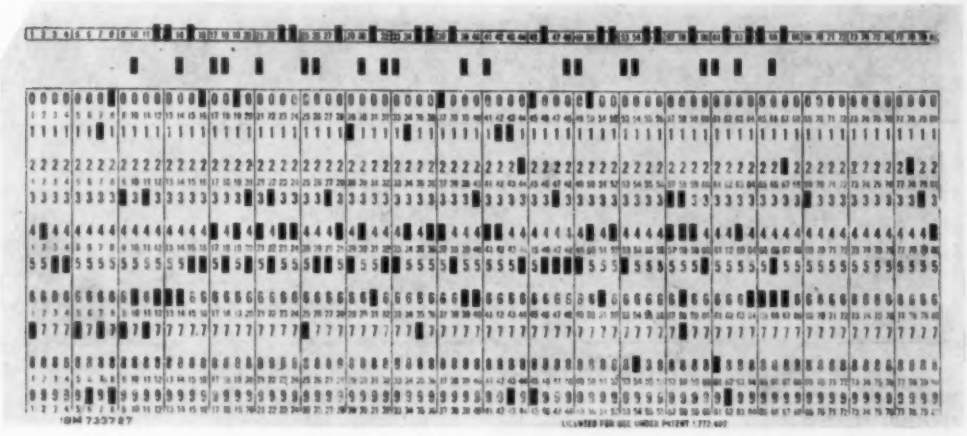
ever, in most Bell System studies where the customer fills out the questionnaire, the practice is either to send it to him through the mails or to employ the "leave-and-pick-up" procedure.

Mailed Questionnaires have been used to advantage especially in connection with subjects which have previously been explored rather thoroughly in personal interviews. Studies conducted on this basis can be administered from a central point, and are particularly advantageous where people from whom information is wanted are widely scattered or where "family" expressions of opinion are desired.

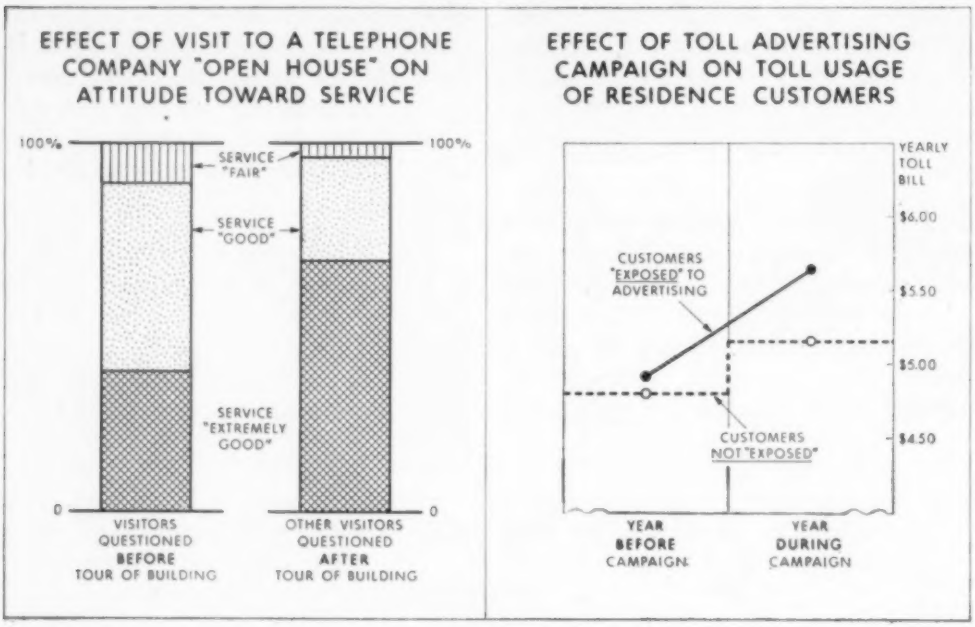
In using the mailed questionnaire method, the possibility must always be reckoned with that people who fill in and return questionnaires may differ from those who do not. Accordingly, in order to minimize any effect which such differences may have on the results, special effort is always directed toward getting a high return. If the subject is of interest, if the questions are not too difficult, and if the approach and follow-up are well planned, a satisfactory return of completed questionnaires can usually be obtained.

The "Leave-and-Pick-Up" Method is a relatively new development in System studies. In this procedure a questionnaire is left with the customer to fill out; and later on, the same day or the next morning, it is picked up. The method was first tried out in a survey in Rochester, Minnesota, early in 1943.

This method, as compared with face-to-face or telephone interviews, materially speeds up the field work, because the interviewer does not have to wait while the questions are being answered. Since the individual reads the questions himself and records his own responses, any influence which interviewers might have on results is largely eliminated. Moreover, it is



THE HOLES on this card record all the information given on one questionnaire



How SURVEYS were used to determine the effectiveness of two specific public relations activities. Left, people's opinion of the quality of their telephone service improved after a visit to a central office. Right, the toll bills of people "exposed" to advertising increased more than did the bills of people who had not seen the advertising

possible to conduct the surveys with a less skilled field force than where interviews are involved.

Little difficulty is experienced in getting people to fill in the questionnaires; and most of those who agree to fill them in, do so. The fact that the questionnaire is delivered by a representative of the company preserves some of the values of personal contact of the face-to-face interview. The customer can fill out the questionnaire at his convenience; and since it is left outside when completed, the person is called to the door but once. Help of other members of the family in filling out the questionnaire can be secured if necessary.

Analyzing Results

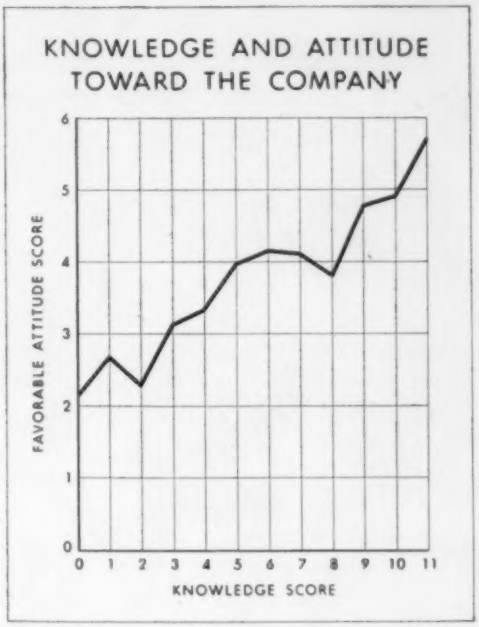
IN SUMMARIZING the results of a survey, machine tabulating methods are almost always used. This usually involves "coding" the questionnaires: that is, translating the responses to the questions into numerical codes. When coded, the questionnaires are given to a punch card operator who perforates tabulating cards according to the codes shown. A separate card is prepared for each questionnaire and the cards are then run through sorting or tabulating machines which provide a record of the responses to each question.

These responses, expressed in percentage form, are generally significant

in themselves. They gain added meaning, however, when comparisons can be made, for example, between different groups—such as dial and manual customers, individual and party line customers, and so on. Or the results in some specific locality may be compared with other places, with "company" figures, or with "Bell System" totals. Particularly enlightening are trend comparisons, where results are compared with those of previous studies made in the same locality.

ANOTHER method of analyzing results is by studying the way in which answers to various questions are interrelated. To illustrate: in recent surveys in rural areas each customer interviewed was asked whether he would be interested in "semi-selective" ringing—an arrangement whereby each customer hears the rings of only one other party on the line. Elsewhere in the questionnaire he was asked whether he objected to others "listening in" on the line. By relating the answers to these two questions, it was found that people who objected to listening in were much more interested in the new ringing arrangement than those who did not. This provided a pretty clear indication that one reason for interest in this type of ringing was a feeling that less listening in would result.

Through this "indirect method" of analysis, it is often possible to obtain indications of the reasons which lie behind things people think or do. This is particularly important where reasons are of the type which people might tend to cover up if questioned about directly; or where motives are involved which individuals may not be too well aware of themselves.



THE MORE people know about the business, the more favorable is their attitude toward it

In addition to determining specific relationships, it is also frequently desired to investigate relationships of a more general character—and in these cases "scoring" procedures are usually employed.

In one survey, for example, it was desired to find out the extent to which people's knowledge of the business seemed to affect their attitude toward it. In this study, the extent of the individual's knowledge of the telephone business was determined by using a series, or "battery," of questions; and on the basis of responses to these questions, each individual was assigned a "knowledge" score. General attitude toward the company was measured by another battery of

HOW 80,000 PEOPLE WAITING FOR TELEP
Feel About Us and Our Efforts to Serve
MEET DR. ASK'EM
THE SURVEY MAN
"AS OTHERS SEE US..."
We Held A TOWN MEETING
DOWN ON THE FARM
What do our Hold Order Customers Think of Us?
6,800 Residence Customers Answer
We've Quizzed Our Waiting List —
Rural Customers Speak Their Minds
On the shelf for WHAT CUSTOMERS THINK
IT'S Easy TO ASK
How Is Your Telephone Service?
This Question Is Being Asked of About 10,000 of Our Customers by Trained Operators in a Series of Attitude and Service Surveys

TELLING EMPLOYEES about opinion surveys and the results obtained is an important part of attitude survey work. Here are some articles published in Associated Company employee magazines

questions, and each individual received an "attitude" score. When knowledge scores were related to attitude scores, it was found that the higher the individual's knowledge rating, the higher his attitude rating tended to be; indicating that the more people know about the telephone company, the better they feel toward it.

Another use for the scoring technique is in determining the public relations significance of difficulties people may have with telephone service—such, for example, as slow dial tone or wrong numbers. In the case of each difficulty, it is essential to know at least two things: first, the number of people who have experienced it; and, second, how much difference it makes to the individual when it does occur. The first figure is simply a matter of counting people. The second is arrived at by comparing the attitudes of people who have and who have not had the difficulty, as measured by a score based on a battery of general service attitude questions. Where the attitude of the people experiencing the difficulty is substantially less favorable than the attitude of the group not affected, it seems reasonable to assume that the trouble is an irritating one; where the difference is small, not so irritating.

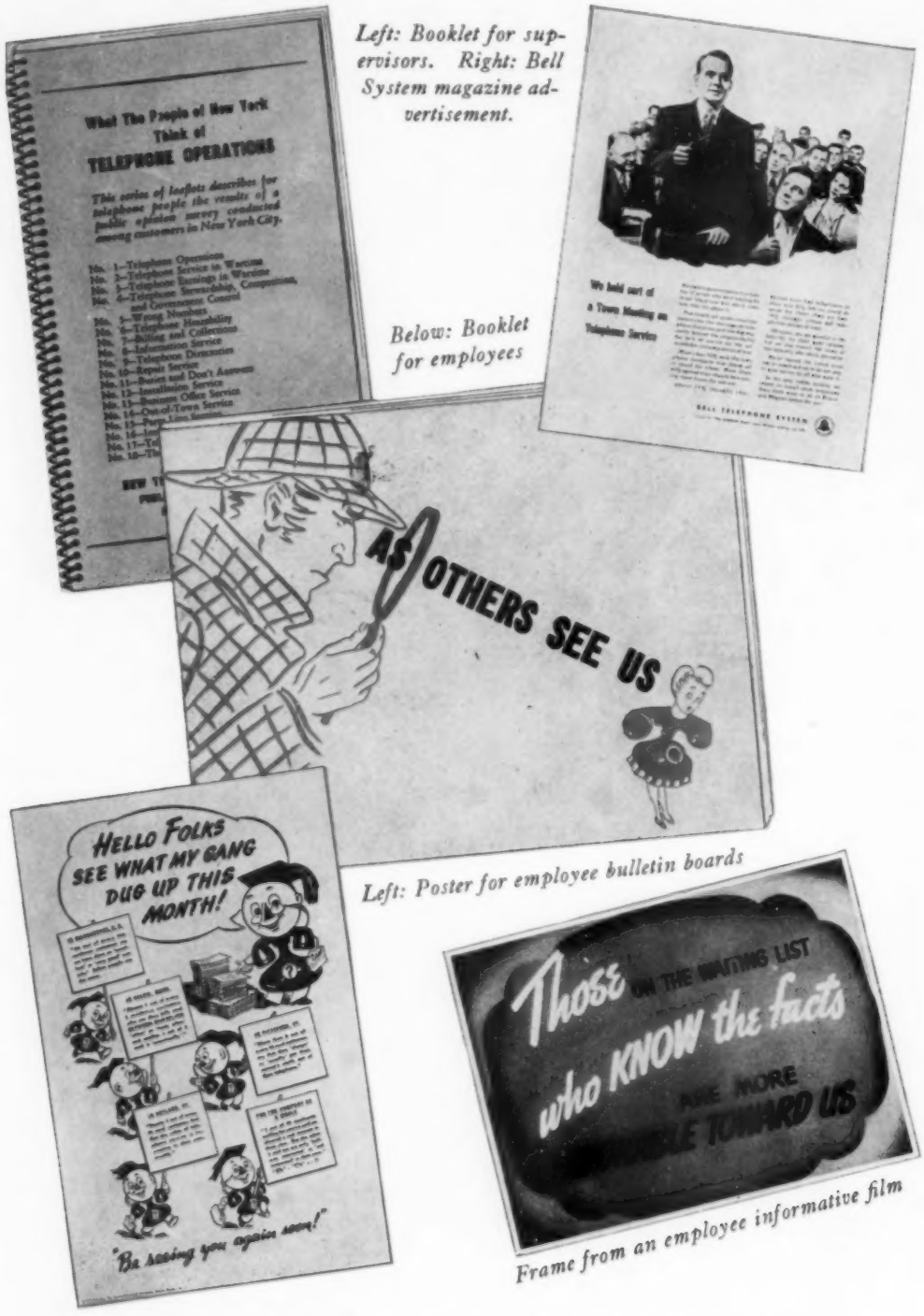
It is particularly important that the basic plan of analysis of each attitude survey be determined upon at the outset, for this affects every phase of the study:—the field to be covered by the questions, the exact form the questions are to take, the procedure to be followed in obtaining the answers, and the methods to be used in summarizing and analyzing results.

Looking Ahead

IN RECENT YEARS various studies have been undertaken on a System basis in which most of the companies have participated. During the war period, for example, surveys of the opinions of applicants who had to wait for service were made by almost all of the companies, and most of them also conducted opinion studies among rural telephone subscribers. Some of the companies are making surveys to determine the service needs of non-subscribers in rural areas. Others have inaugurated *continuing* studies of the attitudes of their customers toward telephone service.

These surveys and others have demonstrated the value of a coördinated research program. And it must be borne in mind that the success of such a program depends in large measure on the extent to which an effort is made by management and by supervisory people to determine how the findings of attitude surveys may be used to greatest advantage in helping to solve the problems of the business.

Research of the type described in this article can be of particular value at a time when new problems are arising and previously established precedents no longer seem to apply. Looking ahead, many changes in operating methods can be expected—changes which will affect directly millions of telephone users. Public opinion is in a constant state of flux; changes in opinion seem to be occurring at an accelerated rate, and this may be expected to create many new customer and public-relations problems.

The fact that the Bell System is entrusted with supplying telephone

What The People of New York Think of
TELEPHONE OPERATORS
This series of leaflets describes for telephone people the results of a public opinion survey conducted among customers in New York City.
No. 1—Telephone Operators
No. 2—Telephone Service in Wartime
No. 3—Telephone Damage in Wartime
No. 4—Telephone Ownership, Competition, and Government Control
No. 5—Wrong Numbers
No. 6—Telephone Reliability
No. 7—Billing and Collections
No. 8—Information Service
No. 9—Telephone Directories
No. 10—Repair Service
No. 11—Buzzes and Don't Answers
No. 12—Installation Service
No. 13—Business Office Service
No. 14—Out-of-Town Service
We held part of a Town Meeting on Telephone Service
BELL TELEPHONE SYSTEM
AS OTHERS SEE US
HELLO FOLKS SEE WHAT MY GANG DUG UP THIS MONTH!
"Be seeing you again soon!"
Those ON THE WAITING LIST
who KNOW the facts
ARE MORE

Left: Booklet for supervisors. Right: Bell System magazine advertisement.

Below: Booklet for employees

Left: Poster for employee bulletin boards

Frame from an employee informative film

VARIOUS MEANS are used to publicize the results of opinion surveys

service to the great majority of the people in this country places large responsibilities on its Associated Companies. Since telephone service is an essential service, the public has an important stake in the welfare of the telephone business, and should be interested in many of its problems. For example, the public is directly concerned with the adequacy of telephone company earnings if the service is to continue to expand and improve.

In promoting mutual understanding, a continuous inward flow of information from the public seems essential. In order that the System may be assured of keeping abreast of changes in public thinking, a project has recently been inaugurated which calls for periodic soundings, on a nation-wide basis, of public opinion toward the telephone business.

Equally important, of course, is the outward flow of information from the company to the public. Every year the Bell System devotes a considerable amount of effort and money to keeping the public informed about the telephone business. Many different methods are employed to reach the public with our messages. If our informative activities are to be along the most productive lines, we need information regarding the public's reaction to them, and all the evidence obtainable as to their effectiveness.

The reputation of the telephone company as a business organization is determined primarily by the quality of its service and by the skill and understanding used in its day-to-day contacts with the public. If the telephone companies are to provide good service, they must know what the user expects in the way of service, and what he likes and does not like about the service he is getting. One of the most important functions of the research activity should be to supplement the present internal measurements and indexes by providing continuing measurements of the quality of service from the public's point of view.

IN DEALING with the many problems of human relations which characterize the telephone business, there is obviously no substitute for sound judgment on the part of management. But the more facts management can command, the better that judgment will be.

There is probably no business in the country more adequately equipped than ours with accounting, statistical, and engineering records on which to base operations. There is probably no business where progress has been more dependent upon factual knowledge developed through technological research. And there is every reason to believe that facts regarding the many human—and hence intangible—aspects of our business can be made available through the application of the research technique; the same systematic, painstaking method of inquiry which has brought the physical facilities for telephone communication to their present high state of development.

Special Efforts and Arrangements by the A. T. & T. Long Lines Department Have Enabled Thousands of Members of Our Armed Forces Overseas to Telephone Home

Three-Minute Furloughs

Harold A. White

AT 2:20 P.M. on Thursday, February 21, 1946, a nervous G.I. stepped into a telephone booth in Titania Palast, Berlin, and picked up the receiver. Three minutes later, flushed and jubilant, he came out, the first soldier to call the United States from the German capital. He had talked to his folks back home in Philadelphia. "Nothing to it," he said, "but, brother, it's amazing. Clear as a bell. Talked to my wife, mother, father, sister. Recognized all their voices."

A few weeks previously, on the opposite side of the world, an American soldier had emerged from a telephone booth in Tokyo greatly reassured. First to call from there since the war, he had talked to his wife, who had been ill, in Wichita, Kansas.

Those calls were two among thousands that our men have placed from foreign lands. "Three Minute Furlough" is the name that *Stars and Stripes* * gave to these brief but precious contacts with home which overseas radio telephone service has made available to the men and women in the services. Those two calls were notable because they marked the climax of the job of restoring overseas telephone service to war-torn areas.

For the war had disrupted overseas service to many foreign points.

In 1939, when the United Kingdom and France went to war against Germany, calls to and from the United States were limited to government business. In 1940 France fell, and the New York–Paris circuit went silent.

After the Jap attack on Pearl Harbor, the circuit to Japan was turned down when an operator in Tokyo said that she could accept no further calls—in the circumstances, rather an understatement. Service with Germany and Italy was suspended when war was declared.

Early in 1942, as the Japs were approaching Manila, the Manila station reported that the privacy device,

* Available evidence indicates that the phrase may have been first used in *The Caribbean Breeze,* publication of the Sixth Air Force.

which might have been valuable to the Japs, was out of order for an indefinite period and a less modern device was being substituted for it. Code words were established daily for contact, to be sure that service was with our own people and not the enemy. Then, with the fall of Manila, another circuit became silent. The loyal Filipinos had smashed the privacy equipment and dumped it into Manila Bay.

Thus, while service with South America and the Caribbean remained available to the public, in Europe only Switzerland, Spain, and Portugal maintained commercial service; and in the Pacific, only Hawaii. All calls to and from the United States were subject to censorship after the attack on Pearl Harbor. Meanwhile, much of our equipment on these shores went to war as a fundamental part of the Army's world-wide communications network and for use in short-wave broadcasts by the O.W.I.

The American Theater

WHILE our service men were in the States, assigned to military stations throughout the country, many of them eased the transition from peacetime pursuits to the business of war by telephoning home.* When they reached points beyond the continental United States, their desire to call home was increased rather than diminished. And here the Bell System overseas service brought to many an American a means of doing just that. For example, after that disastrous December 7 of 1941, the Hawaiian Islands developed rapidly into a concentration center as troops massed there for the push toward Japan. Recognizing the need for telephone facilities for service people, the Mutual Telephone Company of Hawaii promptly established a telephone center for overseas calls and, in coöperation with A. T. & T.'s Long Lines Department, increased the number of radio telephone circuits between the Islands and the States. Over these circuits thousands of soldiers and sailors were able to get that brief "furlough" home.

AFTER FOUR YEARS: a former prisoner of war talks by radio telephone with members of his family for the first time

This service was in many cases not only the "last chance" for those headed out but also the first contact for those on the way back. Early last Fall hundreds of liberated prisoners who had spent four years in the filth and despair of Japanese prison

* See MAGAZINE: "Service for Service Men," Feb. 1943; "'I Knew Then I Was Home,'" Autumn 1944; "That First Call Home," Autumn 1945.

camps made their first contact with home by calling from Hawaii, an experience that they and their loved ones alone could fully understand and appreciate.

In Panama, the troops and naval personnel guarding the Canal Zone showed a similar eagerness to call home. The Tropical Radio Telegraph Company, too, set up a telephone center in Panama City to accommodate service men, and this center became an oasis for Americans whose hearts were, after all, in the U.S.A. Prospective callers arrived from outlying military centers by the truckload, and "the trucks are in" from the Panama operator to the New York operators was the warning of a flood of calls to all parts of the United States. Similarly, from Puerto Rico, and in South America on the air route to Europe via Africa —from Curacao, Paramaribo, Recife and Rio—Americans in increasing numbers talked with home.

To the thousands of service people stationed in Alaska, telephone service was available by means of radio facilities operated by the United States Army Communications System. The circuits terminate at Seattle, where they are interconnected with Bell System wire facilities for the completion of calls throughout the United States. Service men stationed at Nome, Adak, Anchorage and other Alaskan points have found this conversational link with the States of great value. Some

OUTPOST OF HOME: HAWAII. There many men released from Japanese prison camps had their first voice contacts with their loved ones. Here several are waiting to talk home

2500 calls a month, most of them personal calls by G.I.s, have been completed from Alaskan points via the Army's radio system.

The European Theater

IN THE winter of 1944, as the prospects of victory in Europe became daily more encouraging, the Bell System began to plan not only to restore the overseas services that had been disrupted but also to create an overseas system which would meet the needs of the post-war world. From the growth of traffic among those services still operating, it was apparent that the future needs of the world for international telephone service would be many times greater than they have ever been; that America had new responsibilities, and would assume a new place, in the world. And—of most immediate importance—at the close of the war many Americans would be in foreign lands, eager for the sound of voices from home.

As to conditions in enemy-occupied territories, nothing was known concerning the state of the radio telephone equipments nor the land-line systems; but it was a safe assumption that much had been or would be smashed to bits in the path of the retreating enemy.

At about the time that the Germans were retreating north of Rome and were being forced back on the Rhine, a representative of Long Lines began arrangements in London with the

MEN by the truckload poured into Panama City to place calls to the United States

governments of Norway, Belgium, and Holland, then in exile, for the resumption of the war-interrupted service to their countries. He also visited Rome and Paris, hardly yet cleared of the enemy, to lay the foundation for restoration of telephone service with the United States. For both the Army and A. T. & T. recognized that it would be most important to the morale of American occupation forces to provide them with a means of telephoning home.

THE BRITISH set up a radio telephone center near London's *Rainbow Corner*

Arrangements with Great Britain

TO THESE ends, plans went forward, looking toward both the immediate needs of the G.I. and the ultimate communications needs of a world at peace.

Shortly after V–E Day, arrangements were made with the British General Post Office to make the overseas service, which had been limited to official calls, available for public uses.

At that time the British communications system was still greatly overloaded because of bomb damage, war-time shortages, and post-war readjustment needs. It was at first thought that, because of this serious congestion, the system could not take the added burden of G.I. calls from all parts of the United Kingdom and therefore overseas calls should be limited initially to those originating at a telephone center in London. However, General Post Office officials said that they wanted to give all American fighting men in Britain an equal opportunity; that the British people were grateful to them and anxious to accommodate them. They

therefore willingly assumed this additional burden, and public telephone service between all of Great Britain and the United States became available on June 23, 1945.

The response of men and women in uniform to this offering was immediate and heavy. Additional circuits were quickly added between New York and London, but bookings ran days in advance. A Long Lines Club. The center fortunately adjoined a pub, and it became the custom for G.I.s to be paged at the pub when their calls were ready.

In certain parts of Britain, it is common for public telephones to be mounted out of doors, as are fire boxes in this country. One sergeant placed a call from one of these boxes and then took his blanket roll to the box and slept beside it until his call

THE London-New York circuits were swamped at first

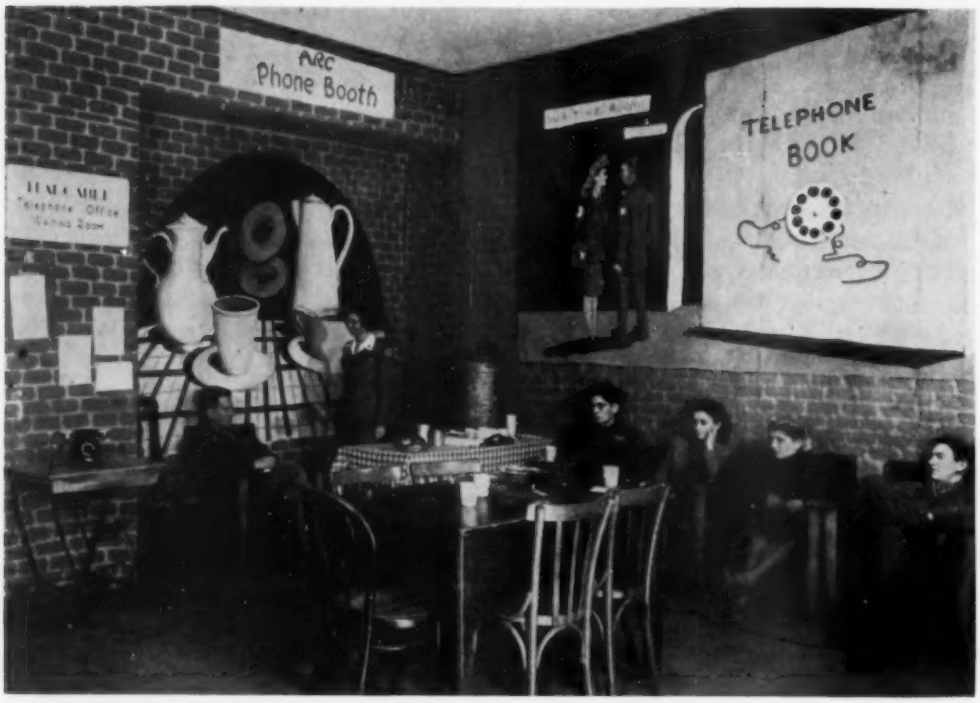
traffic representative thereupon flew to London to work out, in coöperation with traffic experts there, procedures which would speed the flow of messages; and representatives of the GPO came to New York for the same purpose.

The GPO established a telephone center on Shaftesbury Avenue in London, near Picadilly Circus and the famous *Rainbow Corner* Red Cross was completed. A number of soldiers on leave on the Continent hitchhiked to Britain on Army planes to get in a call home.

Some 9,000 calls a month were completed, most of them for men and women of the American services.

When in Rome

WHEN the Allied Command took over in Rome, it found the telephone



THE RED CROSS decorated the room in Rome where members of the American services waited for their calls back home to come through

system of the city in a deplorable state. Nobody could place a call with any certainty of completing it. Transmission was poor and cut-offs frequent. However, the Germans, in retreating, had sent non-technical troops to destroy the radio transmitting equipment. At the station they found some massive but obsolete long-wave transmitters which they thoroughly destroyed—fortunately leaving the smaller, modern short-wave equipment virtually intact. At the direction of the Allied Commission, and with the assistance of the U. S. Army Signal Corps, Italcable Company conditioned the equipment and established contact with the United States.

Because the telephone system in Italy was in such poor shape, it was decided that overseas service for both G.I.s and all other users in Italy would be confined to a single booth location near the Pincio Gardens in Rome. Here, beginning on July 1, 1945, calls were booked, scheduled, and completed to the United States. The demand was so great that it was necessary at first to limit all calls to three minutes, in order that as many as possible might enjoy the privilege. The Allied Commission found that G.I.s, impatient to complete their calls, became restless when inevitable delays occurred. At such times, a loudspeaker was switched on in the waiting room and the voices of the operators working on their calls could

be heard. Such evidence of activity on the circuit, and the sound of American voices naming American towns and cities, relieved the tension considerably.

This efficiently run unit, which handled as many as 3500 calls a month, became a model for terminals which were later set up in other war-torn areas. When long distance lines became available to northern Italy, overseas telephone centers were also established at Udine and Leghorn.

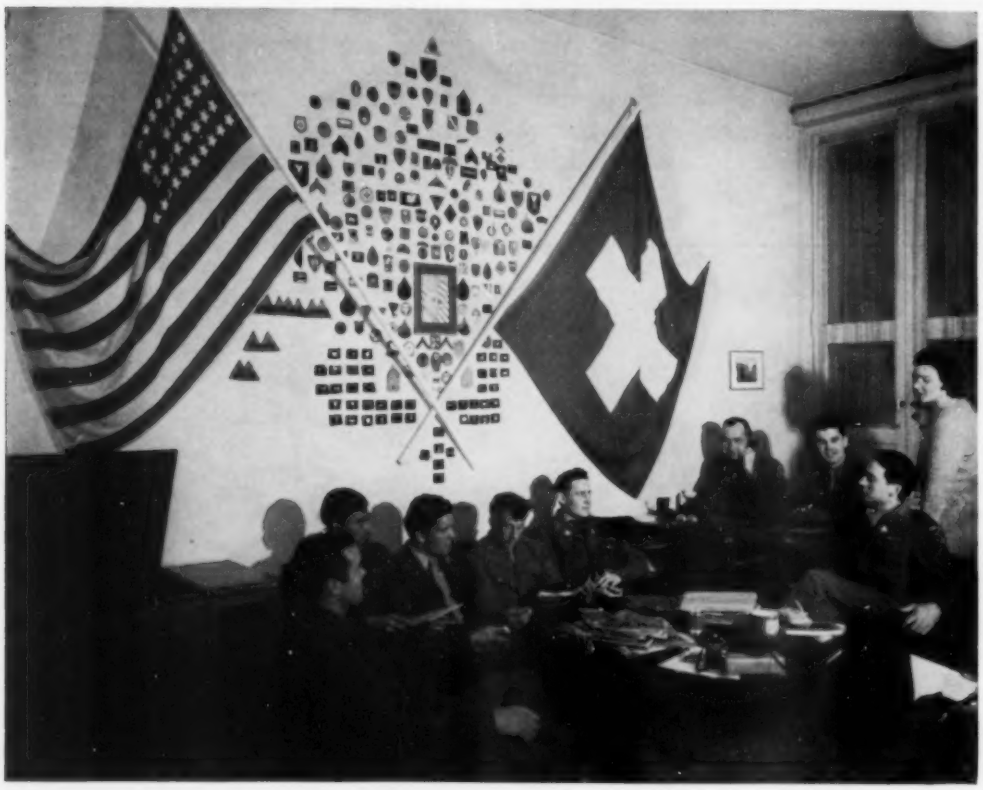
At Pontoise, near Paris, the retreating Germans made a determined effort to destroy radio equipment, and particularly that formerly used for service to America. This they smashed into pieces no bigger than a man's hand. They imprisoned the staff, blew up one end of the building, set it afire, and withdrew.

The French freed themselves, and saved part of the building; but it was necessary for the Ministry of Posts, Telegraphs, and Telephones to obtain new equipment from the Western Electric Company in the United States before service could be restored. A Long Lines representative spent several months assisting the French Telecommunications Admin-

AN AMERICAN SOLDIER and his French bride, in Paris, talk with the former's parents in the U. S.—the Parisienne reading a typed statement in English as her contribution to international good will

istration to install and test it. He encountered many difficulties while working in buildings which were without adequate heat and light. Power was rationed, and subject to frequent interruption, and little items, such as bolts and screws, which can be obtained in any hardware store here, were major supply problems in Paris. U. S. Army personnel gave informal but able assistance to the project.

Overseas service with France was re-opened to the public on November 7, 1945, and again Americans eagerly crowded to telephones. Despite the many handicaps resulting from enemy invasion and occupation, the French telephone system had been sufficiently restored to permit interconnection to the overseas system, thus making the service available to users throughout France. A telephone center was opened on the Champs Elysees for American soldiers, and men on leave in Paris flocked to it in such numbers that it was found impossible, with the limited facilities available, to handle the rush.



SOLDIERS visiting Switzerland on leave find it easy to make calls to their homes in this country

"SIG-CIRCUS," originally the Army Signal Corps's mobile overseas radio telegraph station, located near Frankfurt, Germany, was leased by A. T. & T.'s Long Lines Department and modified to handle telephone conversations

MEMBERS OF THE U. S. Forces may make telephone calls to the United States from eight cities in Germany. In this booking office in Frankfurt—as is the rule everywhere—people take their turns regardless of rank

It was necessary, therefore, to close this center temporarily, and calls were completed instead through public and private phones.

Switzerland, surrounded by combatants, maintained service with the United States throughout the war—although with difficulty. Improvisations were necessary to make up for wartime scarcities, and vital parts, such as vacuum tubes, were several times flown into the country via Portugal. Soldiers began to visit there after V–E Day, first in small numbers and later in larger groups under an organized leave program sponsored by the Army and the Red Cross. The Swiss Administration of Posts and Telegraphs, one of the most competent communication agencies in Europe, promptly made plans to meet the natural urge for soldiers there to call the United States. A second radio circuit was added with Berne, and soon 4000 soldiers a month were pouring their greetings across the Atlantic to the folks at home.

For G.I.s in Germany

IN GERMANY, the U. S. Army quickly recognized the advantages to the welfare of the occupation troops of having radio telephone service available to the States. But Germany was smashed — politically, economically, and physically. There was no equipment available, no constituted authority to operate it, no organization remaining upon which a nucleus of a public telephone system could be built. So the Army asked the Long Lines Department to establish service by operating both the German and American ends of a radio telephone system. This was an unprecedented step. It was tackled, nevertheless, in the interest of the G.I.s' needs.

Army radio equipment which could be modified for telephone service was available in Frankfurt, and the Army agreed to lease it to Long Lines for this purpose. Known in the Signal Corps as the "Sig-circus", it was a multi-channel single-sideband telegraph system mounted on trucks, complete with power supply, and was used from advanced areas in Europe to establish direct communication with Washington.

In early December, 1945, fifteen Long Lines men and a couple of tons of special Western Electric Company equipment were flown by Army plane to Frankfurt to establish the service. It was a pretty tough job, and this

little group was very much on its own. All about them lay the vast ruins of a nation prostrated by war. Communication, transportation, supply were virtually non-existent—excepting as they had been restored by the Army for Army purposes.

To get service going took a lot of doing. The radio equipment had to be modified for telephone use, conditioned, and tested. Arrangements had to be made with the Army for the establishment of suitable telephone centers in eight cities in the American Zone, and land lines connecting the other seven with Frankpassport. They finally were stopped by a Russian who apparently didn't smoke, and so spent the night in the guardhouse.

The U. S. Army gave the fullest assistance in every phase of the undertaking, and provided our men with living quarters, transportation, and supplies. Army-approved German civilians were recruited to assist in both the technical and operating phases of the work. During time off from their duties, G.I.s were glad to help out as operators or as assistants in the calling centers.

On January 10, 1946, preliminary

furt had to be established and tested. Meanwhile, there were the tasks of staffing the centers; working out details for the booking and handling of calls and the handling of funds; establishing a switchboard at Frankfurt; and arranging a coördinated schedule for operating it. In fact, these Long Lines men had to put their hand to almost all the jobs which have to be done to make a telephone system work.

They had minor adventures, too. Though armed with credentials, two Long Liners, travelling from Berlin through the Russian occupied zone, found that cigarettes were the best

work was completed and service was opened to the United States from Frankfurt and Munich. On successive weeks Heidelburg, Nuremburg, Bremen, Kassel, and Stuttgart were linked on; and by February 21 the network was completed with the opening at Berlin.

Only calls placed from Germany could be handled, because of the difficulty and delay which would have resulted from trying to locate soldiers to receive calls placed by their families or friends in the United States. The response to the service was, to the telephone men, a gratifying reward for their efforts.

The service was originally established with two transatlantic telephone circuits and a teletype order circuit over which booking information and call reports were passed. Soon a third telephone circuit had to be added; and with this arrangement, calls have been completed at the rate of some 7,000 a month.

A FRIENDLY SPIRIT pervaded the telephone centers, and the soldiers cooperated splendidly in following the calling procedure. Usually each caller emerged from the booth wreathed in smiles and pretty well set up—although emergency calls, which were given priority when certified by the Red Cross and a unit chaplain, sometimes brought distressing news from home.

Calls were booked in advance; and at booking hours the men counted off in the line the number of calls allotted for that day—as shown by a placard in the office window—and the rest went away, to come back and try again the next time. One morning at 3:00 o'clock a pair of weary Long Lines men were closing up the center in Nuremburg when they were approached by a soldier wrapped in a blanket. "Where does the line form?" he asked.

At Bremen one morning a G.I. came in to call his mother in Brooklyn. When he heard her voice he jumped up and down in his excitement until he crashed through the floor of the booth into a hole that happened to be beneath it. He completed the call, with his head just visible through the window, bellowing up to the transmitter. He climbed out of the booth, said he had had a fine talk, made no other comment, and walked out smiling. Stout planks were installed in the booth, and service was continued.

A boy from Oklahoma called home from Kassel one stormy day and walked out of the center in a dream. Five minutes later he came back, drenched to the skin, and said, "Reckon I'd better take my hat and coat along."

The Pacific Theater

OUR FORCES in the Pacific gots lots of service too. Service with Australia was re-opened to the public on September 15, 1945, and immediately carried capacity traffic, many calls being made by G.I.s stationed there. A direct U. S.–New Zealand circuit was established for the first time on October 25, 1945, offering another link to American soldiers and sailors "down under."

The Supreme Command for the Allied Powers in Japan likewise wanted service to the States for service men, and asked the Bell System to send a representative there to assist in establishing it. Arriving in Tokyo in November, 1945, he found the destruction and disorder characteristic of conquered territory. However, unlike Germany, Japan was not completely disorganized, since the structure of the Japanese Imperial Government had been maintained.

The Board of Communications of Japan was still to some extent a going concern under military direction, and it was attempting to restore communications to meet the Army's needs. The radio equipment and the essential units of the control equipment were found to have escaped the B-29s and were intact, although in very poor condition. Here also the land-line system was in too sorry a

state to permit connections with the overseas circuit. At the direction of the Army, and under the guidance of the Long Lines representative, the Japs prepared the equipment for service and established and organized a telephone center for overseas calls.

The Long Lines man, in commenting on the attitude of the Japanese who worked on the project, said, "I had to give up thinking out loud, because what I thought were just ideas the Japs took as orders for execution pronto." For example, looking at a littered corner of the room which was to become the telephone center, he had remarked wryly, "This ought to be OK when we get it painted and pictures on the wall and flowers around." On opening day several oil paintings graced the walls and a small vase held a single orchid.

On January 10, 1946, everything was in readiness. English-speaking Japanese operators, trained by an Army lieutenant who had studied Japanese in college, covered the switchboard, Jap technicians manned the equipment, and the first call was completed. At first, because of the great demand, only calls involving emergencies at home were accepted, but as the kinks were ironed out service was made available to all G.I.s and other accredited personnel in Japan.

IN JAPAN, the details of calls to this country are handled by the Army, but Japanese operators set up the connections

MEANWHILE, Manila was struggling toward rehabilitation after enemy occupation and the ruin created by the bitter fighting when the city was re-

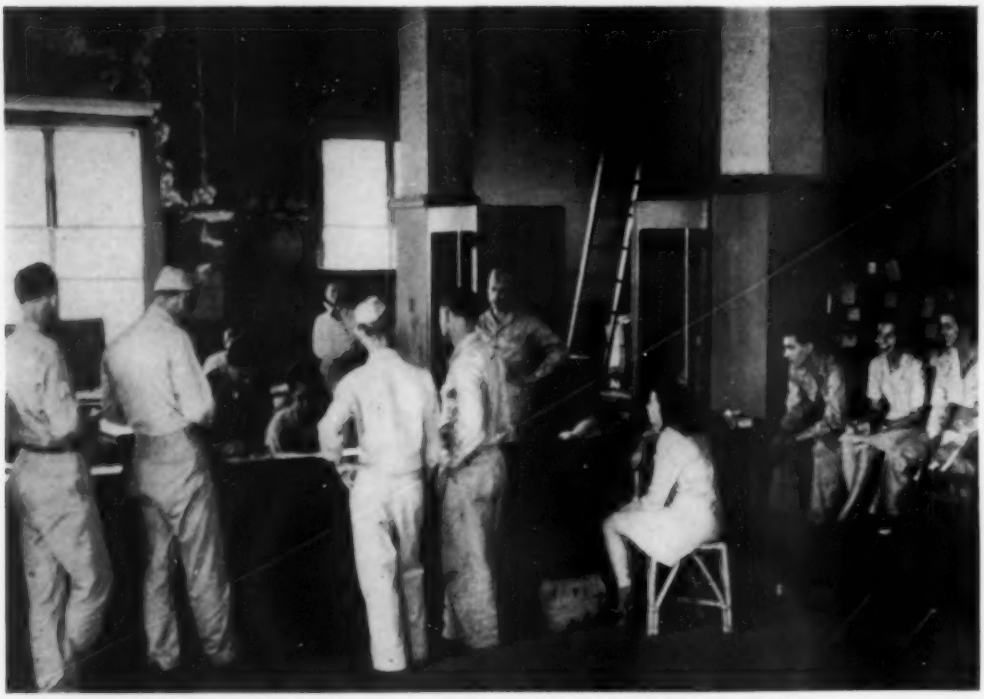
taken. The main building of the Philippines Long Distance Telephone Company in downtown Manila had been reduced to rubble, but an office building nearby which could be used was still standing. It was shell-splattered and surrounded by wreckage, but needed repairs were soon made. The radio equipment had been completely destroyed, however.

New equipment to replace it had been ordered prior to V–J Day, and installation was started—under difficulty—as soon at it arrived.

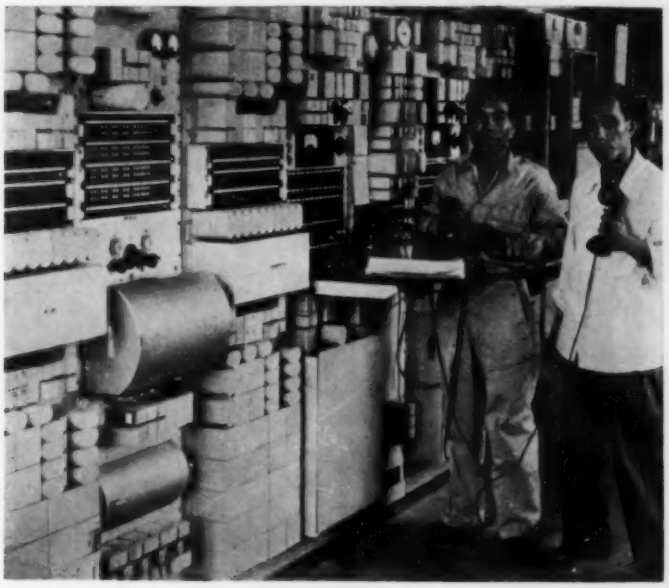
Filipinos who had survived the enemy occupation returned to their old jobs. One of them, a Philippine Army lieutenant, had lost his fingernails under Japanese torture. Some of the technicians and operators returned with small but valuable items of equipment which they had taken home before the enemy arrived and had hidden during the occupation.

Service with Manila opened in January, 1946. By that time the Manila exchange area had been sufficiently restored to permit direct overseas connections to a limited number of telephones in the city and at military and naval establishments nearby. A telephone center of the familiar pattern was set up in the downtown area.

Booking of calls from this center began immediately, and was for a time considerably in excess of the capacity of the two Manila-San Fran-



TWO-WAY telephone service between Manila and this country was restored last January. Here Americans in the war-torn Philippine city are booking calls and waiting to talk



NEW EQUIPMENT, ordered from Western Electric before V-J Day, had to be installed in Manila before telephone service with the United States could be resumed

cisco circuits as G.I.s eagerly placed calls to all parts of the United States. Through the efforts of the Philippines Company, arrangements were made whereby, despite the limited facilities available, people in the United States could call men stationed in the Manila area, and many people in this country have availed themselves of the opportunity. Because many of the men called could not be located, the Philippines Company hit upon the scheme of publishing daily lists of "men wanted" in the Army paper "Pacifican"—which often drew them to the center. Here too some 2400 G.I.s each month have been able to gain that priceless "three minute furlough."

WHILE AMERICANS have grown to accept the telephone instrument and the job it does as a commonplace in this country, to many members of the Armed Forces in the strange surroundings of foreign countries this familiar service has taken on a special worth. Since V–E Day more than a quarter of a million calls by Americans in uniform have been completed from far-distant points by means of the overseas services. The Bell System is proud that, with the coöperation of telephone administrations abroad, it has made possible this host of conversations which have contributed so greatly to the morale, the happiness, of the American men and women stationed around the globe.

TRAFFIC COP OF INVASION: the Laboratories' "beachmaster" adaptation of a Bell System public address loudspeaker (above). Truck-mounted rocket launchers (below) in action using a fire-control device developed by the Laboratories

The Special Knowledge, Skills, and Form of Organization Of the Bell System's Research Unit Contributed in Many Ways to the Prosecution of the War

Bell Laboratories' Rôle in Victory

Philip C. Jones

I. Telephones at War

THE WAR-TIME CONTRIBUTIONS of the Laboratories were by no means limited to direct instrumentalities of war.* Both the Army and Navy required also many types of communication systems, and their development was undertaken by the Laboratories as a matter of course.

Military telephone instruments—microphones, headsets, and loudspeakers—should be designed to pick up and deliver messages and orders with high intelligibility under the noise of battle. They should be convenient and easy to use with a wide variety of equipment. They should withstand the rough and varied usage of modern warfare.

Noise is one of the chief obstacles which has to be overcome in devising instruments suitable for the Armed Forces. Another consideration is that of varying climatic conditions. Still another is the occurrence of rapid temperature and pressure changes—as with a plane rising or descending sharply. Instruments must be designed, therefore, to operate over an extremely wide range of conditions.

An important requirement is that all instruments must be designed to fit into the paraphernalia used by the Armed Forces. Microphones, for example, have to fit into and become an integral part of oxygen masks, and to be used with noise shields, under gas masks, and other similar equipment. Receivers are used in tank helmets, aviators' helmets, and under those of the Signal Corps men.

* See MAGAZINE: "Electric Brain," Winter 1943–44; "Bell Laboratories in the War," Winter 1944–45; "Radar and Bell Laboratories," Winter 1945–46.

LEFT to right: ANB standard receiver, lip microphone, transmitter with noise shield

With all these instrument demands, it is highly important from the manufacturing and supply standpoints to employ a few basic transmitter and receiver units which can be adapted to all of the military uses.

Receivers and Microphones

A HEAD RECEIVER UNIT which largely overcame extraneous noise by both its electrical design and its use of soft-rubber ear pads was designed by the Laboratories and designated by the Joint Radio Board as an ANB (Army, Navy, British) standard. The receiver unit was equipped with a molded phenol-plastic case having stepped contours to fit the various headbands of the Armed Forces. The headset is used by ground forces, bomber crews, and wherever protective helmets are not required. The same receiver without a headband is placed in aviators' helmets.

A small headset was required to fit under the steel helmet of the service men; and for this, receivers of the audiphone type were employed. These are only seven-eighths of an inch in diameter and are equipped with soft-rubber ear plugs. A wire headband attached to them can be bent to fit the user's head and lie snugly under the steel helmet.

Microphones must exclude from the telephone line or radio transmitter as much as possible of the noise that is present. Three methods have been used to obtain this exclusion.

One method is to make the instrument relatively insensitive to noise. The throat microphone does this. It consists of two transmitter units worn high up on the neck with a unit pressing against each side of the throat. Speech vibrations are transmitted to the microphone through the neck tissues; and inasmuch as the microphone is designed to pick up mechanical vibrations of the throat rather than the acoustical vibrations in the air, a fair degree of discrimination between noise and speech is attained. The over-all response of the throat microphone, however, is not all that is to be desired, because chiefly the low-frequency throat sounds are trans-

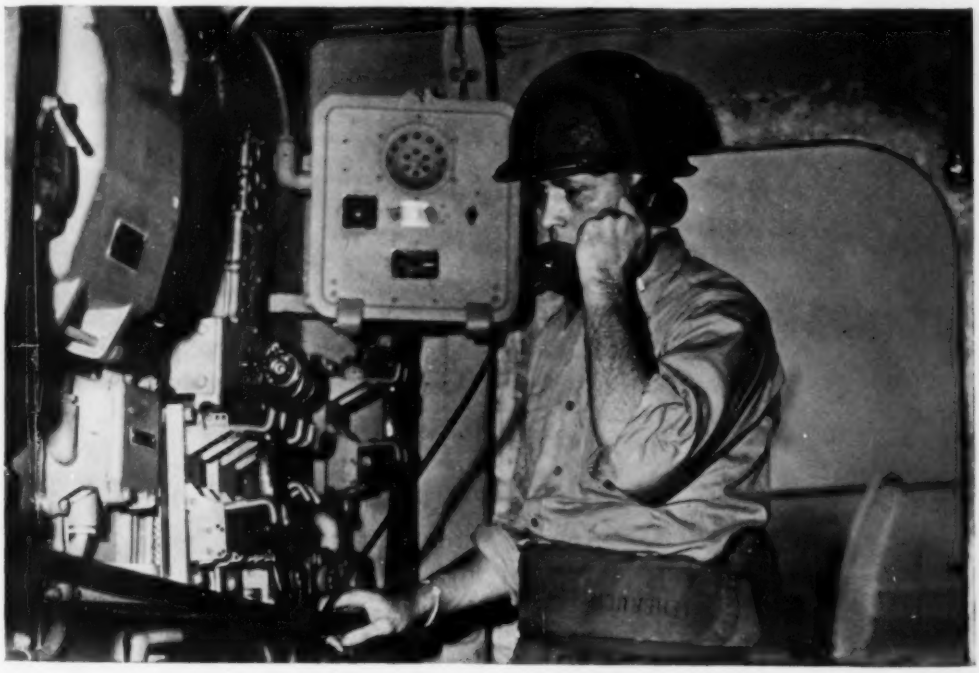
mitted; the high-frequency sounds which are formed in the oral and nasal passages are not included in the proper proportion.

Another way of excluding noise in the microphone is illustrated by the noise shield. This unit has a granular-carbon microphone unit built into it, and is worn over the mouth and nose. A good degree of noise exclusion is obtained, and at the same time the speech transmitted is of a high order of intelligibility because sounds from both the nose and mouth reach the microphone.

The aviator's oxygen mask is similarly a noise shield, and actually forms the mouthpiece for the microphone. The microphone design was coördinated with the design of the oxygen mask, and the unit—of either the granular-carbon or magnetic type—was standardized for the Army, Navy, and British oxygen masks.

The third method of restricting noise from the microphone, and one which provides a good degree of discrimination between speech and noise, is by the use of the lip microphone. The principle of this microphone is very simple. If a diaphragm is open on both sides, noise will reach it with substantially the same intensity and phase at each side, and therefore will tend to cancel out. Then when one talks very close to one side of the diaphragm, the speech will actuate the diaphragm principally from that one side, and hence the ratio of speech to noise transmitted will be high.

This microphone is equipped with a harness so that it can be worn on



A SOUND-POWERED TELEPHONE in use aboard a U. S. warship

the lip, making the speech path to one side of the diaphragm very short. It can also be used with many of the devices provided by the military services, and has been standardized for Army and Navy use.

Sound-powered Telephones

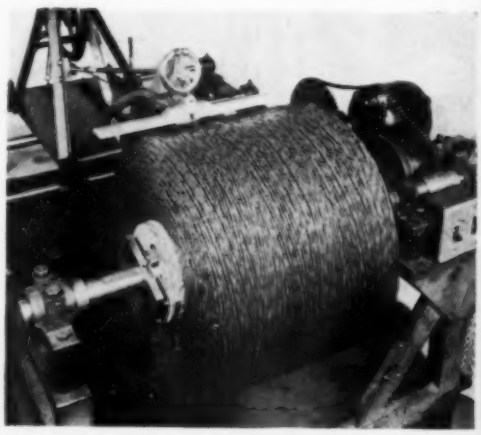
ANOTHER GROUP of military telephone instruments includes the sound-powered telephones. A sound-powered instrument is one which is dependent solely on the voice as its source of energy. No battery or other external power supply is used. The sound-powered transmitter is a generator which creates the voice-modulated currents transmitted over the line. At the receiving end there is a similar instrument in which the transmitted frequencies are reconverted into speech. Bell's original telephone was a sound-powered instrument.

Although the principle of sound-power is not new, the instruments of the type used in the recent war have been improved by the use of high-grade magnetic alloys, which have permitted good efficiency with a substantial reduction in size of instruments.

Sound-powered instruments are built in a variety of forms, such as handsets, headsets, and chest sets. Used extensively aboard ship for fire control and other command purposes, they replaced speaking tubes, which in the old days ran from one end of the ship to othe other. Being entirely independent of an external power source, sound-powered instruments supply effective emergency communication even though the ship's power has been entirely crippled.

Another use of sound-powered instruments, which is rapidly gaining favor, is in portable field telephone sets for use where dry cells, with which most of these sets were then equipped, either did not operate effectively or had a very short life. With Army field wire lying on the ground but in good condition, sound-powered instruments operate satisfactorily up to eight or ten miles.

Flying Telephone Wire



IN ORDER that it may pay out rapidly and smoothly from an airplane in flight, the field wire is wound on a special machine into criss-cross coils

EARLY IN 1944 the Air Technical Service Command requested the Laboratories to study the possibilities of laying telephone wire from the air—and to do it on a rush basis. It was specified that standard Army field wire be used, a flying speed of 150 miles per hour was designated, and the maximum length of wire to be laid in a single flight was put at 15 miles.

An outdoor laboratory was set up at Murray Hill, N. J., including a 40-

foot tower near the top of which experimental packs of wire might be placed. In a building several hundred feet away, a motor-driven drum was located by means of which wire could be drawn at speeds up to 200 miles per hour from the coils or packs in which it was wound. At this laboratory the performance of various types of coils and packs was studied with the aid of high-speed cameras and electrical devices.

Flight testing was also speeded by establishing a field laboratory in a building provided by the Air Technical Service Command at Fort Dix Air Base and assigning to it a Laboratories flight testing team. A total of well over 200 test flights were made—in which the performance of the various types of coils and packs, as well as inter-coil splicing methods, were thoroughly studied.

In the standardized system two wires, twisted together as manufactured, are wound on a specially designed machine into "criss-cross" or "universal" coils, similar in form to the balls of lacing twine used by the telephone installer. Each coil contains one or two miles of wire, depending upon the type, and each is

SIXTEEN MILES of field wire are coiled within the boxes fastened securely in this plane, the outside end of each coil spliced to the inside end of the next coil

encased in a square wooden box with a hole in each side about one-half the outside diameter of the coil.

When a mission is to be flown, the number of boxes required are loaded into a C-47 plane, lined up in echelon from the open doorway to the forward end of the cargo space, and secured to the floor. The outside end of each coil is carefully spliced to the inside end of the following coil. The inside end of the first coil is led outside the plane through a pipe about six inches in diameter and brought back into the cargo space, where it is attached to a weighted parachute. After taking off, the pilot flies over the starting point of the line as identified by landmarks or panels on the ground, and a member of the crew throws out the parachute. As the wire thrums out from the pipe at speeds up to 250 feet a second, it settles to the ground with the parachute. Eventually the other end of the wire pulls free of the plane and is picked up by the second ground party.

Success was soon attained in one-mile flights. Gradually, the number of successful runs increased, and the test lengths mounted from one mile to two miles, and then to four and six. Finally a successful 15-mile run, the specified maximum, was made over the flat, woody terrain of Fort Dix.

As finally turned over to the Army Air Forces, the system may be used with C-47 cargo planes to lay either a new plastic-insulated (polyethylene) wire or the heavier present standard field wires used by the United States and Great Britain.

The Spiral-4 System

ANOTHER communication system, for an entirely different service, is the Spiral-4 cable system. It employs a four-conductor cable developed by Bell Laboratories in coöperation with the Signal Corps. The cable can be buried, laid on the ground, or suspended in the air. The system provides three telephone channels, including both voice and carrier frequencies, and four telegraph circuits. Voice frequencies are heard satisfactorily up to forty miles without amplification. All the channels can be amplified by a single compact repeater. These are spaced twenty-five miles apart and extend the range to two hundred miles.

The cable is made in quarter-mile lengths with quick coupling connectors at each end to permit extending a circuit to any desired distance. In each connector, one of the pairs of conductors is loaded with small coils also developed by the Laboratories.

Copper strands, individually insulated, are twisted together to form "spiral four" conductor. Strength is provided by enclosing the cable in a braid of small high-strength steel wires. A tough rubber jacket completes the four-conductor cable.

This system extends the distance over which telephone communication can be quickly established by our field forces.

Air Warning Systems

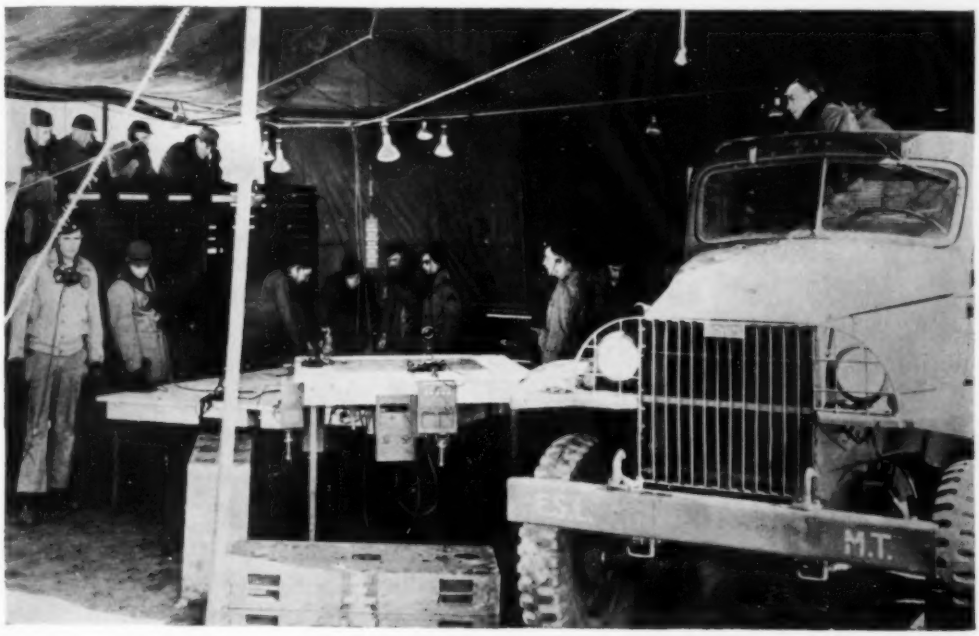
BEFORE THE Pearl Harbor attack, an elaborate communications network with permanently located "filtering" and "information" centers had been established along our seaboard to combat possible air raids. Thousands of airplane spotters located at scattered points reported to the filter centers all planes observed. Here the various re-

ports were checked against each other, the positions of the planes were indicated on large maps, and suitable instructions would be issued —if required—to the various fighter commands, other Services, and Civilian Defense authorities.*

The Army Air Force, which had been responsible for the development of the coastal system, recognized that similar systems and centers would be required in the overseas theaters to control our tactical air forces. As a result, the Laboratories undertook the design of portable equipment along similar lines but modified to meet conditions on the fighting fronts.

In coöperation with the Laboratories' engineers, the Army Air Force set up the requirements, and during the early development stages, discussions were also held with the Navy and Marine Corps to insure that the equipment developed could be used by all the Armed Forces.

The development of the new portable operations center, called the AN/TTQ–1, had two main objectives: a reduction in size and weight to achieve greater portability and less effort in setting up or dismantling; and a simplification of the equipment to facilitate operation and maintenance. Since the equipment might have to be transported by cargo plane and set up in buildings with narrow doors and stairways, it was specified



AN AN/TTQ1 portable operations center installed in a tent

* See "Telephone Lines and Air Defense," MAGAZINE, February, 1942.

that no package should weigh more than 250 pounds nor be greater than 4 feet in any dimension, nor more than 2 feet in at least one dimension. To facilitate the stacking of the packages for shipment no dimensions other than 1, 2, or 4 feet were to be used at all.

Operations Center AN/TTQ–1 consists of communications equipment needed to receive and evaluate military information on aircraft for a geographical area, and to direct the action required by the information received. Information on all friendly and enemy aircraft in the area involved is received by telephone or radio and plotted on a large table map. Platforms carrying a bench and table are placed around the large map table for use of Air Force personnel, who can watch the activities indicated on the table maps, pass information to other interested military agencies, and order the proper action to be taken. Since such procedures involve fighter planes, radio contact must be maintained from the Center to planes in flight.

In addition to air warning and fighter-control functions, the Marine Corps and Army Ground Forces have found this equipment useful in anti-aircraft artillery control. In a great many cases, the equipment would be located in a building or under a tent, and it was therefore arranged to mount the platform positions and cabinets in 2½-ton Army trucks for use as mobile centers.

The equipment as shipped from the Western Electric Company is complete in every detail, and needs only gasoline and oil for the engine alternator, a shelter, and personnel for its operation.

II. Giant Voices

THROUGH ALL the turmoil, noise, and apparent confusion of an invasion beachhead, strict control of the movements of troops and material must be maintained by the beachmaster who—acting as traffic cop and dispatcher—directs the incessant flow of foot and mechanized power. His indispensable assistant in the latter phases of the war was the Western Electric beachmaster announcing system, technically known as the Navy PAB–1 Public Address Set. (See picture on page 36.)

But for this equipment, the voices of those in authority would be drowned out by the noise from the very machines and men they were endeavoring to keep in efficient order and deployment. With its help, however, commands are instantly heard by all to whom they are directed, and there is no loss of time in relaying messages through a chain of command.

Growing from experimental, small-scale use of loudspeaking equipment in early amphibious moves, the PAB–1 became available to the Navy early in 1944. It was used for the landing at Iwo Jima, and played its part in most of the rest of the Pacific landings. Thousands of these equipments were delivered to the Navy for use in the Pacific Theater before the end of the war, and their applications reached far beyond original expectations.

A close relative of the PAB–1 set is the ship-mounted landing-craft announcing system, whose major components are interchangeable with those of the former. Direct two-way speech communication is thus made possible between ships and shore.

Classed by the Navy as semi-portable equipment, the PAB–1 Public Address Set consists of a loudspeaker, an amplifier, a gas-engine-driven alternator, and accessories and spare parts. The complete system is packaged as six individual units in rugged water-tight reinforced steel carrying cases with detachable covers. Each case is designed for its particular component and has ample buoyancy so that, if the occasion requires, it may be dumped overboard and floated ashore.

The loudspeaker is a 3×3 assembly of nine receivers coupled to nine horns and mounted on a yoke and tripod. The useful range of the PAB–1 naturally depends on local conditions, and will vary in different locations. When a greater area of coverage than that of a single system is needed, it is possible to operate two amplifiers and loud speakers from one engine alternator and one microphone. Similarly, when still greater coverage is needed, one microphone may be used to operate four amplifiers and loud speakers powered by two engine alternators.

After these Public Address Sets have done their part in helping to establish the beachhead, they may move on with the advancing troops or may remain to direct the continuing flow of supplies, machines, and troops. At forward command posts they have been used for surrender demands, and for conveying essential information to the troops when other means are either lacking or too hazardous to use.

The Voice of Ship Command

IT IS NOT ONLY on invasion beaches, however, that high volume public address systems are required to override the noise of battle. Consider, for example, a battleship plowing silently along at night in enemy waters.

A BOS'N pipes the crew to attention over the ship's announcing system. A typical system installed on a battleship includes eight transmitting stations, 294 loudspeakers, seven local announcing circuits, and 31,000 feet of cable

The shrill scream of the bosn's pipe startles a sailor from slumber. A few seconds later, wide awake, he hears a "Bong! Bong! Bong!"—the repeated bell-tone of General Alarm. This means an emergency. He listens

carefully to the announcement which follows, telling him the cause of the emergency. It might be a fire, a call to battle stations, or any other serious condition, and he goes quickly to the station he has been trained to man in such an emergency.

These alarms and instructions come through the Battle Announcing System, with which all of the two or three thousand men aboard a large warship are informed of trouble and given any necessary special instructions.

THIS IS one of the more spectacular but less usual uses of the announcing system. Every few minutes during the day the equipment is used for the more prosaic job of calling together a group for a work detail, paging an officer, or summoning the men to mess. It is the means by which all general commands are transmitted to the crew, members of which may be in any of the hundreds of separate compartments on the vessel. As many as two hundred or more loud-speakers are distributed throughout the ship.

Announcing equipment on shipboard is divided into several separate but interrelated systems. The general system might well be termed the commanding officer's system. Announcements on this system are usually made from the point of ship control: the bridge while under way; the quarter deck while at anchor; or the central station, deep in the most protected part of the ship, during special conditions.

The engineer's system is primarily intended for use by the Chief Engineer in giving instructions to machinery spaces. On aircraft carriers, the aviators' system provides for instructions to hangar and flight deck. These systems are tied in with the general system, however, so that alarms and general orders can be sent to all spaces.

Each turret on cruisers and battleships, incorporating a maze of compartments and intricate machinery, has a special two-way announcing system over which the turret officer gives orders for operating the turret and the loading, aiming, and firing of the guns.

The larger anti-aircraft guns are under the control of an officer at an anti-aircraft director station, located high up in the ship's superstructure. Loud-speakers at the guns transmit verbal orders from this officer, and also special tone signals to begin and cease firing.

One of the more interesting uses of announcing systems is on the flight deck of aircraft carriers. Several super-power loud-speakers are located on the island structure, and pointed so that the entire flight deck is covered. These loud-speakers form part of the system over which the Air Officer, located at the control station above the flight deck, can give orders to pilots and deck crews during flight operations and while the airplane engines are being warmed up. This system is also used for transmitting warning signals in flight deck emergencies.

INTERESTING design problems arise because of special requirements for service on naval vessels. Short circuits on loud-speakers must not interfere with operation over other loud-speakers. Short circuits or trouble grounds on microphone circuits or

A NAVY PB4Y-Z which carried the "Polly Project" public address equipment to hail the Japs from an altitude of 10,000 feet

control wiring at microphone locations must not prevent the system from being used from any other microphone location.

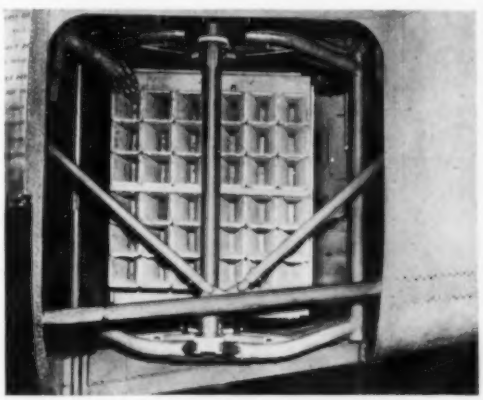
Mechanically, the design problems become even more interesting. Great strength is required, and protection against shock, because equipment must not be rendered inoperative by the ship's own gunfire or the shock of torpedoes or near misses by aerial bombs. Vibration over long periods, caused by the ship's engines, must cause no damage. Loud-speaker and microphone diaphragms must be designed to withstand the blast from nearby gun muzzles.

All equipment located on weather decks must be protected from corrosion by salt water. This includes microphones, control boxes, and loudspeakers. In some cases, equipment is made watertight so that no water can enter. In others, equipment is designed with the expectation that water will enter, and drain holes are provided. Under these latter conditions, all internal parts must be made immune to the corrosive effect of sea water.

Voices from the Sky

THERE ARE still other situations which demand the use of powerful loudspeakers.

After V–J day, voices two miles up in the sky blasted the news of unconditional surrender to isolated Japs still holding out in jungles, caves, and swamps on remote islands of their extensive stolen empire. This new air-borne public address equipment was rushed to Japan to assist in the enormous task of disarming Jap fight-



THE 36 horns of the new "Polly Project" loudspeaker as installed in the plane

ing men and in directing civilian movements.

IN MAY of 1945, the Navy ordered this air-borne public address system, known as the "Polly Project," and requested that it be delivered within one hundred days for installation in three four-engine PB4Y–2s. Bell Laboratories completed the design and the Western Electric Company manufactured the equipments and made them ready for shipment within the short time of eighty-four days. They were capable of being heard and understood on the ground from a height of 10,000 feet.

The Navy order was a direct tribute to an older "Polly" equipment delivered in the early part of 1944. This latter system had a 5000-foot ceiling, and was used successfully for battering down the Jap will to resist on Wotje, Saipan, Iwo Jima, and Okinawa in the last stages of the war. Flying at 2700 feet above Wotje Atoll for instance—within machine gun range—a twin-engine Ventura PV–1 slowly circled the atoll and then sounded off, saying: "Attention, Japanese soldier of Wotje Atoll, attention!" A short news broadcast followed, then a selection of Japanese popular music, a short propaganda talk, and finally more news. The whole program took about fifteen minutes, and was given twice.

These sky programs emphasized straight news broadcasts to isolated Japs completely ignorant of the war's progress. Promises of good food, medical aid, and fair treatment helped coax the Nips into surrendering. On islands occupied by our forces, the Japs were ordered to report to a certain location. On by-passed islands they were told to wait for a landing craft.

After Wotje, "Polly" moved on to Saipan and Iwo Jima. Every day the flack grew thicker, a testimony to the threat of "Polly" to Jap morale, as verified by questioning of Jap prisoners. "Polly" landed on Okinawa one month after the invasion. By that time the plane was so badly battered, it soon had to be abandoned after first removing the equipment.

AS A RESULT of these experiences, the Navy specified that the new "Polly" should be capable of operating at a height of 10,000 feet so that the plane would be out of range of machine gunfire. This meant that a completely new system had to be designed.

In it, microphones are provided for direct broadcasting, and in addition, two magnetic-wire recorders are provided to permit continuous broadcasting of previously prepared messages or the recording of information broadcast from the microphones. Two control panels are supplied to give the flexibility needed for switching from live to prepared broadcasts, and for connecting to the intercommunication system on the plane.

Bell Laboratories' engineers supervised the building of the equipments at the Western Electric Company, and later coöperated in installing and testing the equipment in all three planes at the Naval Aircraft Modification Unit at Johnsville, Pa. Each plane took off for Guam and points west as soon as the tests were completed.

III. The Rockets' Red Glare

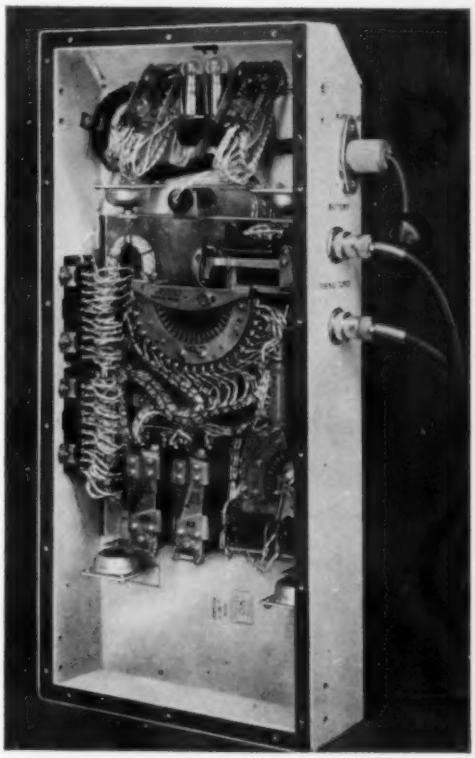
COÖPERATION accounted for much of the difference between success and failure in the late war. Practically all information was pooled to make it available where it could best be applied; and tools, plants, and personnel were used for the best over-all good. It was in this spirit of coöperation that the Laboratories lent one of its engineers to the National Defense Research Committee. During the first World War, he had had some experience with the experimental development of rockets as military projectiles. More than 20 years later, with the outbreak of the second World War, he suggested that rockets had a number of military applications. By the end of July 1940, he had been sworn in as chief of a section of the National Defense Research Committee.

Of the long series of rocket developments carried on under this engineer's direction, the one to see earliest combat use was the 2.36-inch bazooka, which became known around the world because of its novelty and effectiveness—even against the giant German tiger tanks.

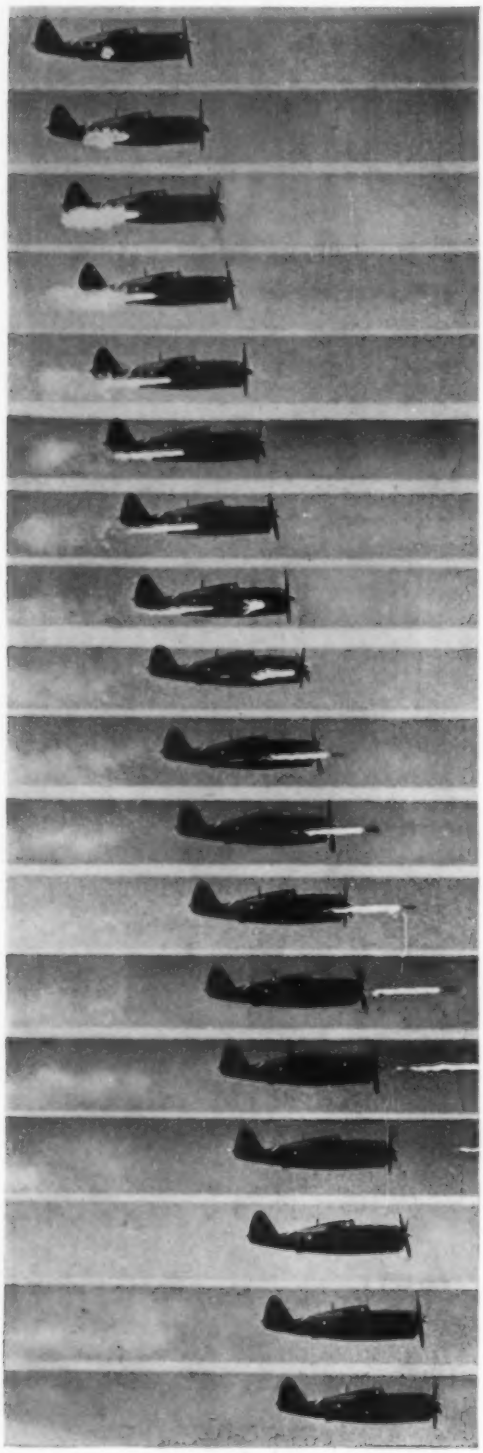
To understand why the rocket is so useful a weapon under certain conditions, one must remember that a projectile weighing several pounds requires a considerable push to accelerate it to several hundred feet per second. When this push is exerted by a cannon, its recoil is heavy—and in proportion to the force of the propelling change. A rocket, however, reacts against the mass of its own gases, and there is no appreciable recoil. The launching tube is not subject to high pressure, but merely serves as a guide, and thus can be light and inexpensive.

Launching "by Telephone"

ONE OF THE many applications of communication techniques to rocket problems was the fire-control mechanisms developed for releasing rockets from multiple-tube launchers. The Army was working on an arrangement to launch 7.2-inch rockets from a large truck. An electrical firing cir-



THE "INNARDS" of the fire-control unit of a multiple rocket launcher, showing the dial-type selector and other standard telephone apparatus (see photograph on page 36).



cuit was needed to set off the rockets in succession under control of a selecting mechanism connected to the truck by a long cable. The problem was to obtain a timed selecting arrangement that would discharge the rockets in as rapid succession as possible without having them collide in the air or having the blast from one rocket affect the trajectory of the succeeding one.

The Laboratories designed a fire-control arrangement around a dial telephone selector with an associated relay timing circuit that enabled the rockets to be discharged in succession as required. Within a week a model was in the hands of the Army, and the Western Electric Company was commissioned soon thereafter to build nearly a hundred of these devices for further field experiments.

This first "ripple" fire-control mechanism attracted attention to similar problems on rocket launchers for tanks and other mobile mounts. On a rush basis, the Laboratories designed fire-control devices for tanks carrying 60-tube launchers, for demolition tanks which threw twenty 7.2-inch missiles for breaking up heavy defenses, and for 8-tube launchers on truck and trailer mounts. All of these fire controls, built around telephone switches and relays, were found to provide greater reliability of firing than earlier designs, and Western

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DEVELOPMENT of a ribbon frame camera, which takes pictures at a speed of from 1/10,000 to 6/10,000 of a second, was an important contribution of the Laboratories to rocket research. This series shows the launching of a rocket from an airplane

Electric was placed under contract to build several hundred of each kind of launcher controls for equipment to be sent overseas.

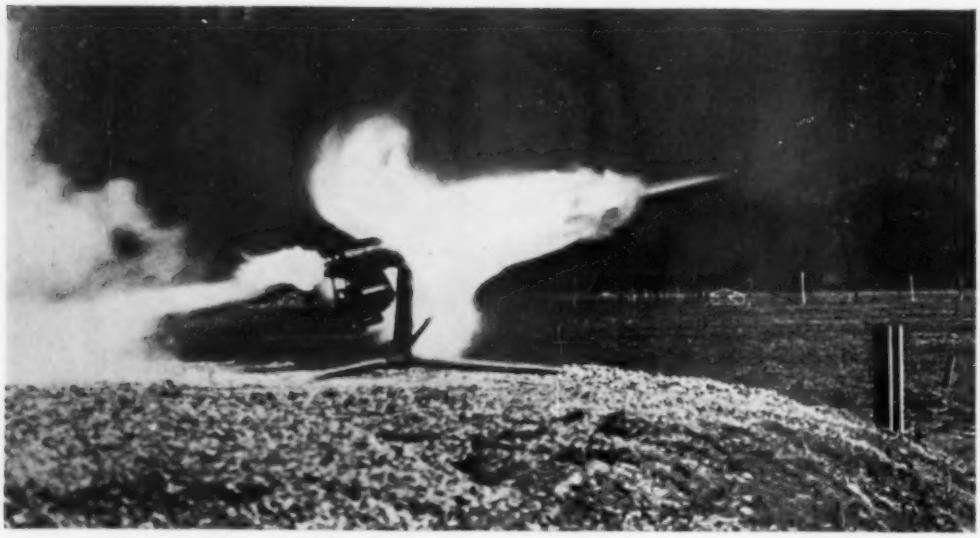
Spinning to the Target

ROCKETS are ordinarily stabilized with fins, and if the propelling charge is completely burned before the rocket leaves the launching tube, the dispersion, or deviation from the desired trajectory, is very small. If the propelling charge burns after the rocket has left the launcher, however, the dispersion may be large unless there is perfect alignment of the nozzle and the center of gravity of the rocket. When this alignment is not perfect, the line of force of the burning gas discharging through the nozzle does not pass through the center of gravity, and a tilting moment is developed which causes the rocket to deviate more and more from its original direction of travel. Such conditions are common with very high speed rockets where the burning cannot be completed before the rocket leaves the launching tube.

Spinning had been suggested to decrease the dispersion under such conditions, but preliminary studies had indicated that a high spin would be required to bring about a worth-while improvement.

To find out just how much spin was needed, a rocket launching tube was mounted in large ball bearings

HERE ARE three groups of exposures of the launching of a rocket from a stationary structure, taken with a wide-angle Fastax camera, developed by the Laboratories during the war



A ROCKET starts its journey, its accuracy increased by the spin imparted in launching

within an outer stationary tube attached to a tripod. Provisions were made for arming the assembly, and a motor was provided to rotate the launching tube at speeds of 900, 1,800, and 2,700 rpm.

With this arrangement, an extensive series of tests was carried out to determine the effect of spin on dispersion. It was found that a considerable decrease in dispersion was obtained with very moderate spins, and that the speed was not critical—essentially the same improvement was obtained over a wide range. Without spin, the dispersion for the standardized rocket was 39 mils: that is, the rocket would deviate 39 feet in 1000 feet of travel, while with spins of 800, 1,400 and 2,400 rpm the dispersion was reduced to 13, 11, and 9 mils, respectively.

The improvement in dispersion obtained in these and other tests resulted in intensive research programs both here and abroad to reduce dispersions by giving the rocket, at the time of launching, a moderate spin.

Other Projects

OF MANY supplementary projects undertaken in connection with rocket research, two are particularly interesting.

The use of copper balls instead of cylinders for measuring pressure in the explosion chambers of rockets and mortars not only proved of inestimable value in ordnance studies, but brought savings several times greater than the total amount the Laboratories spent on all its rocket developments. Copper balls of the required diameter were obtained from ball-bearing manufacturers, but the work of annealing and calibrating them was carried out by the Laboratories, not only during the development stages but on a production

basis until nearly the end of the war.

One of the important tools used in most of the studies of rockets was a high-speed "ribbon frame" camera, especially developed to obtain knowledge of the behavior of rockets during the early part of their flight.

It was by the use of special apparatus and tools of this sort, and through an intensive application of native genius, that American jet propulsion, which was almost non-existent at the beginning of the war, became one of the important factors in our final victory.

THE WAR DEVELOPMENTS here recounted are only a few of those actually carried out. The original design and development were undertaken by the Bell Laboratories, and manufacturing was done for the most part by the Western Electric Company. But every branch of the Bell System made its contribution of trained personnel: either on loan directly to the Laboratories, or on military leave with those branches of the Armed Forces which installed and maintained all sorts of communications equipment under all conditions and all over the world.

Field Engineers of the Bell System's Manufacturing Arm Accompanied Our Army and Navy in All Theaters to Help Keep Electronic Devices at Peak Performance

Western Electric Experts With the Armed Forces

J. Stedman Ward

OUT ON MIDWAY ISLAND early in 1945 a Navy radar technician aboard a U. S. submarine reported having had a brush with a trouble-maker named "Little Joe." He didn't say a word about it to the Intelligence Officer, or to the Shore Patrol either; they wouldn't have been interested. Trouble of this kind was in the province of a fellow who wasn't really in the Navy at all; yet he was certainly *of* the Navy, for the Bureau of Ships had requested that he come to Midway, required that he wear a Navy uniform, and arranged that he be accorded all the privileges of a naval officer.

The man to whom the "Little Joe" trouble was reported was a Western Electric field engineer.

The field engineer had seen Joe, under one guise or another, often enough in the past, and knew him for an old and troublesome offender. Joe was, in fact, a false echo, a little man who wasn't there. For every once in a while the oscilloscope screen of a radar equipment would indicate the presence of an object at short range when, in sober truth, the seas were clear for miles around.

There were four or five standard possible explanations for Joe's presence. None of them fitted this particular case at Midway. Then the engineer remembered an item in a recent number of the weekly *Technical Newsletter* sent to him by the Field Engineering Force headquarters in New York. He checked back, found that one of his five-hundred-odd far-flung colleagues had scotched "Little Joe" on the same equipment by the use of an FE-1088 Oscillator. Within a short hour Joe had left Midway.

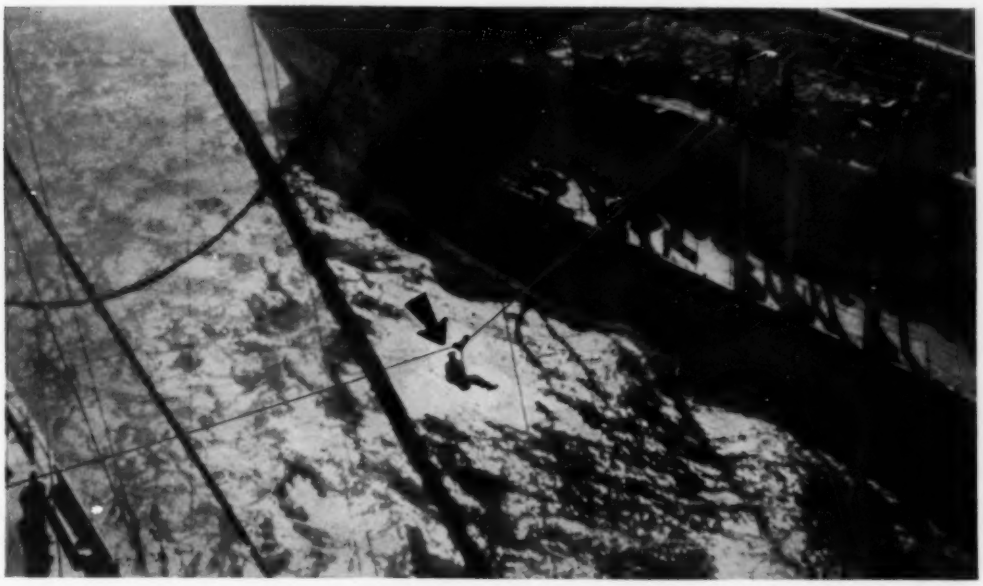
Joe had not always been viewed with such nonchalance, nor had he always been so easy to eliminate. In the early years of the war, he had

been a real menace. When the seas were teeming with Japs and Germans, it was disconcerting, to say the least, to have such a will-o'-the-wisp target bob up every so often. It is even possible that an occasional torpedo was fired at Little Joe. In any case, Joe, in concert with a number of his brother gremlins, threatened to undermine the confidence of Navy crews in the radar equipment which had so recently been given them.

Joe's departure was important, and the fact that it was a *hurried* departure was even more important; but the incident hardly provides more than a hint of the reason for the field engineer being with the military services. In itself, it cannot explain why the Navy requested Western Electric to hire this young man, a former police radio engineer, school him in the new science of radar, send him to the Norfolk Navy Yard for months of additional training and experience, and then ship him out to Midway among the submarines and the gooney birds.

In the five days immediately following that fateful Sunday morning of late 1941 at Pearl Harbor, one of the first Western Electric field engineers, a former ERPI * man, worked 85 hours repairing damaged radar and making new installations.

In October and November of 1945, a field engineer accompanied the 7th



A WESTERN ELECTRIC field engineer on duty in the Pacific changes from one warship to another by breeches buoy to answer a call for expert radar assistance

* ERPI, signifying Electrical Research Products, Inc., a former subsidiary of Western Electric Company which introduced and distributed Western Electric sound motion picture equipment.

Amphibious Corps of the Marines as these troops occupied Northern China to accept the surrender of the Japanese for Generalissimo Chiang Kai-shek. In the engineer's words, it was "more of a social call than an occupation," but the Marines wanted him there as a source of information on their radar equipment.

A MEMBER of the F. E. F., somewhere in the Pacific, goes aloft to get something done. Radar didn't work by decree; it sometimes took a lot of doing

Between these two assignments, so significant in their contrast, lies the growth of the Field Engineering Force from a group of twelve engineers, recruited in 1941, to an organization of more than five hundred field engineers by V-J day, serving our armed forces and our allies on five continents and backed up by a strong Headquarters staff of technical and clerical people in New York.

Why this growth, and what did the field engineers do at home and in strange lands around the world? It is an interesting and, for industry, a rather exceptional tale. The Bell System had a major share in translating radar from a scientific concept to an accomplished fact.* Here, now, is the evidence that the System also accepted a share of the responsibility for putting this fact across to the enemy.

THE MAIN JOB of the field engineer was to bring about the best possible

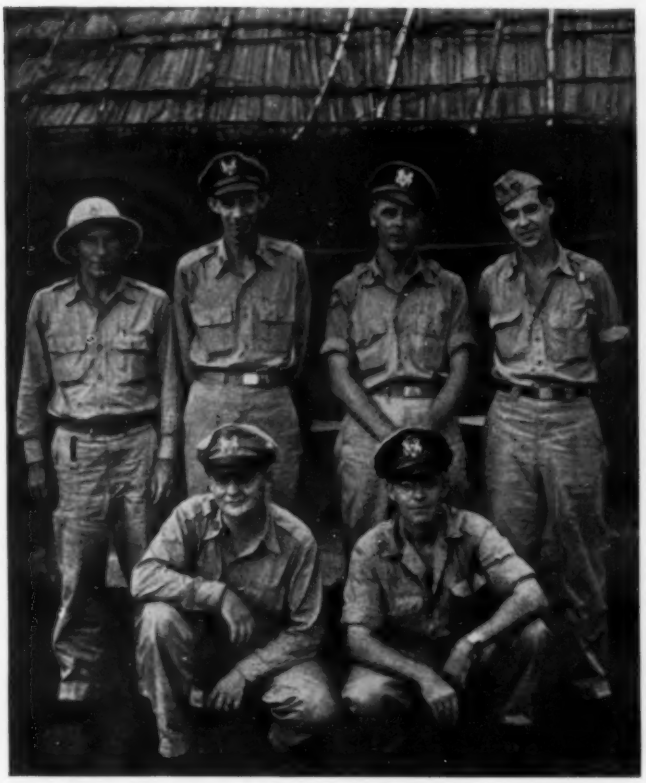
* See "Radar," MAGAZINE, Winter 1945–46.

standards of radar operation in the field. He helped to translate Bell System quality of design and manufacture into high quality field performance. This meant the instruction of officers and enlisted men in the techniques of proper installation, adjustment, maintenance, and operation of radar and, for that matter, sonar, other special electronic devices, and communication systems developed by Bell Laboratories and produced by Western for the Army and Navy.

The insistence upon a high standard of performance meant frequent need for on-the-scene field modifications and readjustment of radar systems and other electronic equipment to incorporate improvements meeting the always advancing technical and operational requirements. This objective involved extensive coöperation with Bell Telephone Laboratories.

Not infrequently, it was the very fact of the engineer's civilian status, his easy mobility in terms of official channels, which made him invaluable. He was able to go directly and immediately to the proper level of command to present suggestions and get the approvals necessary for action.

The field engineer functioned also as a coördinator and expediter. He established a reliable and close technical liaison with the designers and



SPECIALISTS in the high-altitude bombing radar equipment carried by the B-29s. These six field engineers, pictured somewhere in the China-Burma-India Theater, were commended by Major General Curtis LeMay for their contribution to the success of the missions of the 20th Air Force over Japan

factories of his company at home. His presence throughout the armed services proved a considerable factor in building up confidence in radar and other new electronic devices for combat.

It is not an easy thing to summarize the activities of even one of these men. Their work was as varied as the use of radar itself—which, as we know, was employed for scores of purposes, from area bombing of the enemy home-land to zenith search against kamikazes. But actions speak louder than definitions: the pattern of their contribution should emerge from the retelling of several characteristic incidents.

Field Engineers in the Field

Field Engineering Force "branches" served the various armed forces thus—

Bureau of Ships branch—*covered seaborne radar, sonar, and special radio communications for the United States Fleet and the Marine Corps.*

Bureau of Aeronautics (USN) branch—*first for airborne radar and later for electronic flight trainers.*

Bureau of Ordnance (USN) branch—*for radar controlled airborne missiles and later for fire-control radar.*

Army Air Forces branch—*for airborne radar.*

Army Ground Forces branch—*for ground-based radar and wire and radio communications.*

Office of Scientific Research and Development—*for various radars and special equipment.*

Engineers trained and assigned to the work of one branch ordinarily specialized in its activities and remained within its scope.

DURING the early years of the war, aircraft crews were at first inclined to question the value of radar—which, because of added weight, meant less fuel supply and lower speed. A field engineer—a man of 17 years' service with the Illinois Bell Telephone Company—helped to demonstrate what radar, understood and rightly used, could do.

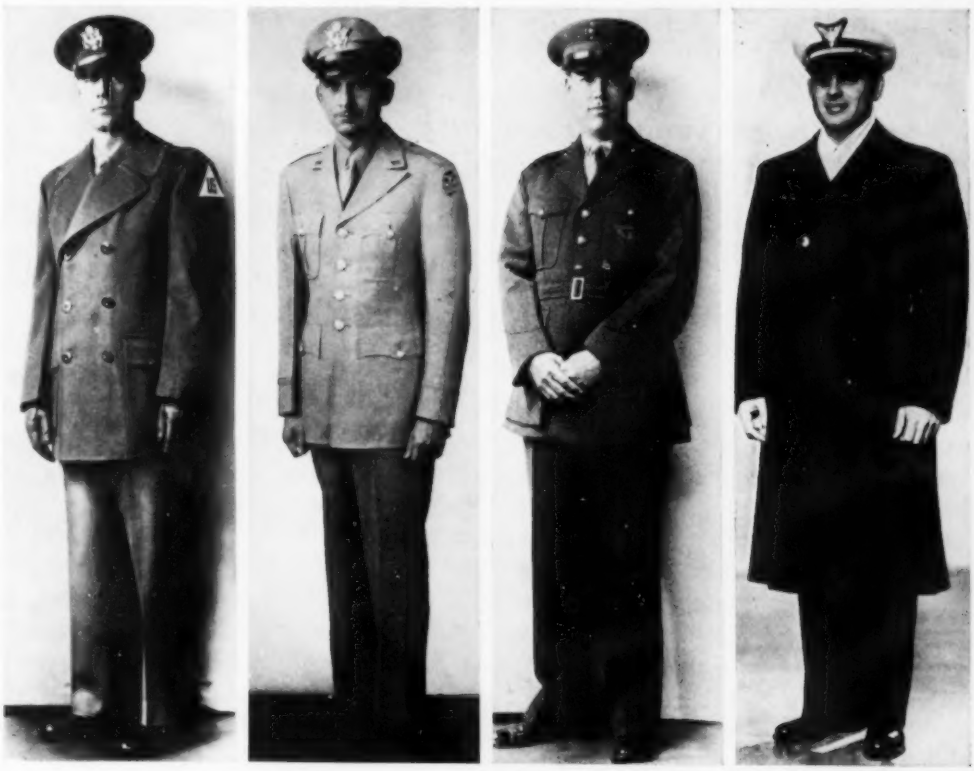
This man spent several months in 1942 and '43 with the B-24 Squadrons' crews of the 480th Air Forces Group, coaching them in their use of radar against submarines. Careful instruction and painstaking trials both in this country and in England had brought no results over the North Atlantic; but by the time the squadrons were transferred to the Mediterranean, things were looking up. In the latter area, during the first two weeks of July 1943, those squadrons sank 13 Axis submarines —a not inconsiderable contribution to the freedom of the seas. Of those 13, nine were spotted and the bombs sent away through the use of radar alone.

That proof of the usefulness of radar *in* airplanes was matched by another field engineer's demonstra-

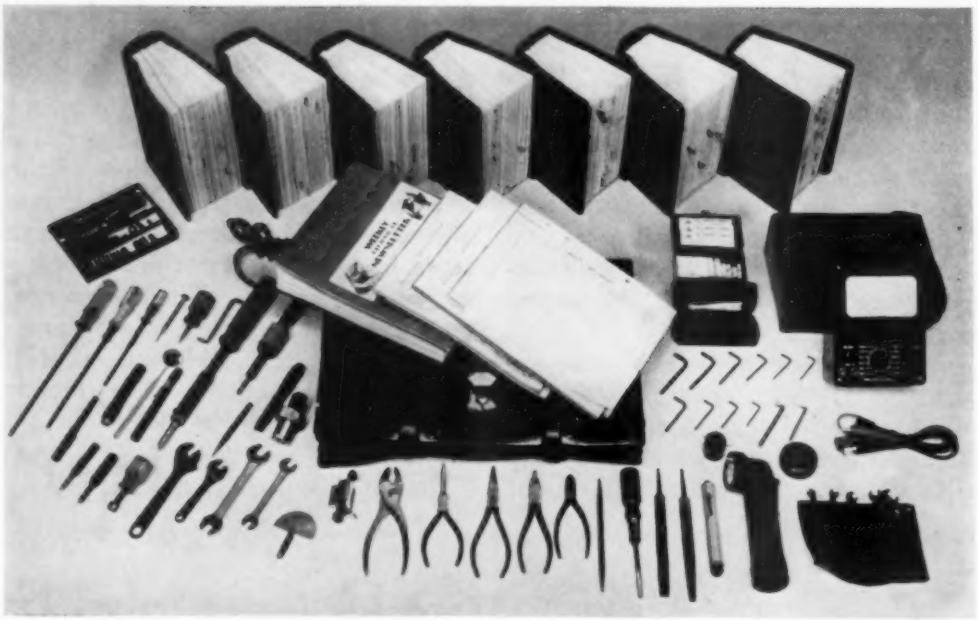
tion of its value *against* airplanes. This man, attached to the 108th A.A.A. Battalion, whose gun directors were controlled by SCR-545A radar equipment, spent long and dangerous hours at Anzio. He helped these artillerymen to locate their equipment to best advantage and taught them how to track their targets steadfastly through the enemy jamming and "window" (tinfoil dropped by enemy planes as they approached). The 108th, which was the first anti-aircraft battalion to be so fitted out, shot down seven enemy planes during their initial radar night action, firing with an effectiveness 2½ times greater than the other two Anzio battalions together.

A colleague in Italy, assigned to the 12th Air Force, briefed the radar officers, navigators, and pilots of the C-47 planes which carried paratroopers from the Galleria Air Field, near Rome, in the August 1944 invasion of southern France. The drop zones, although completely covered by overcast, were discernible to skillful radar interpretation. The troops landed just two minutes behind schedule.

In 1944 and '45, field engineers



IN FOREIGN THEATERS the engineers wore the uniform of the Service to which they were assigned. The four members of the F. E. F. pictured above were with (left to right) the Army Ground Forces, the Army Air Forces, the Marine Corps, and the Navy



IN HIS capacious black bag (center), the field engineer carried his specialized tools and instruments, his Company papers, and as many of the equipment bulletins (rear) as applied to the equipment with which he was concerned

worked with the British branch of the M. I. T. Radiation Laboratory, in England and on the Continent, on problems connected with radars for fast night fighter planes. Some of these men, making their observations and tests right up where the shooting war was happening, discovered an important fact: the planes they were using were so fast that in the dark of night they whizzed right over slow-flying German supply planes almost before their own planes' radars had indicated the enemy's presence. So an engineer devised an answer to that one, involving the use of microwave early-warning radars. Thereafter the night-time deliveries of German supplies by that method dwindled.

In Alaska, field engineers were assisting the cold-weather program of tests on Air Forces' radar equipment at the same time that another engineer, a former Michigan Bell Telephone Company man, was sweating it out in Brazil, learning Portuguese and helping the Brazilian Navy with the installation and operation of ship-borne radar equipment. Between these extremes of North and South in the Western Hemisphere, many field engineers saw service at numerous locations outside the continental United States, including the Canal Zone.

One of the first field engineers to go abroad won't forget the time he inspected and checked the radar aboard the submarine PETO as she rode the seas in the Pacific 40 miles off the Zone. He was taken out to

Best available statistics indicate that Western Electric engineers travelled collectively 11,200,000 miles at least in their globe-girdling operations. They worked 2,200,000 man-hours, and filled 138,000 assignments.

meet her in a PC boat and—the last half mile—in a native dugout canoe!

This same engineer, while stationed in the Zone, witnessed the growing confidence Navy men displayed in their radar equipment as more and more ships followed one another through the Canal in 1942 and 1943 enroute to the fighting fronts. In contrast to the skepticism displayed by many Navy crews handling the earlier radar installations, all concerned with it were by then showing the greatest interest in developing high efficiency in the operation of their equipment.

The advantages of radar, demonstrated in battles won and very effectively circulated via the reliable scuttlebut route, brought about this respect, and created the desire on the part of personnel manning fighting vessels to utilize the equipment to its utmost capacity.

IN THE Pacific, the center of naval activities was of course Pearl Harbor, where eventually two-score and more Western Electric engineers in Navy uniforms handled radar, sonar, and other electronics problems brought in by a steady stream of ships from all parts of the Pacific. But Pearl Harbor served another function too. It was the jumping off place for field engineers heading south to Australia, north to Okinawa, and all stops in between: New Caledonia, Espiritu Santo, Guadalcanal, Munda, Kolombangara, Bougainville, New Georgia, Manus, Ulithi, Eniwetok, Kwajalein, Funafuti, Majuro, Palau, and others.

Engineers were stationed ashore at bases; they lived afloat on tenders, repair vessels, and flagships; and they rode combat ships of all types, traveling hither and yon—wherever the need for their services might take them. More than once they witnessed engagements at sea, and shore bombardments in preparation for landing operations; and they sometimes went ashore with attacking troops.

At Ulithi lagoon another engineer, on loan from the Illinois Bell Telephone Company, worked back-breaking hours checking and tuning radars among the 624 ships gathered there in preparation for the Okinawa invasion. He was so busy that the Navy asked him not to answer a request for assistance unless it was repeated.

A succession of field engineers assigned to the 7th Fleet Submarine Base at Freemantle, Australia, set up a model system and routine for

In addition to conventional automobiles, railroads, surface ships, and aircraft, field engineers rode in or on jeeps, command cars, motorcycles, tractors, tanks, landing craft of all kinds, native canoes, amphibious "ducks," submarines, rickshas, catapult planes, gliders—and probably other vehicles not yet reported.

checking, servicing, and tuning the radars of the big "pig boats." One of these engineers was flown to Milne Bay, New Guinea, where he worked eighteen hours a day for five days on the radar gear of ships destined to take part in the Arawe invasion. When he finished, he himself sailed aboard one of them—the destroyer FLUSSER, which covered the operation and bombarded enemy installations ashore.

Western Electric was one of eight companies manufacturing radar and other electronic apparatus whose field engineers accompanied the Armed Forces. Most of these specialists served with the fleet, and Western Electric supplied the largest single group: 325 out of 1,300. While each engineer was on hand primarily to look out for the equipment made by his own company, many a helping hand disregarded that technicality on occasion, and in an emergency there was no thought of distinguishing among different companies' products

Field engineers working with the Army Air Forces in the Pacific area, by their advisory engineering assistance on radar equipment and problems relating to its use, contributed heavily to the success of our bombing of enemy ships and cities.

Perhaps one of the most impressive evidences of their success in this line was provided by two engineers who accompanied a B-24 Squadron to Guadalcanal in mid-1943. This squadron was the first to be equipped with a radar bombsight designed in a big hurry for low altitude bombing at night. The bombsight was so new that half of the available equipments were pre-production models, and one of the field engineers was borrowed from the Bell Laboratories group which had developed the equipment. The planes went to work and sank everything *not* in sight—even canoes.

The telegram from General H. H. Arnold, Commanding General of the Army Air Forces, to C. G. Stoll, president of the Western Electric Company, commenting on the outcome of these operations, said in part:

I WISH TO EXPRESS MY OWN APPRECIATION AND THAT OF THE ARMY AIR FORCES FOR THE INVALUABLE ASSISTANCE GIVEN BY TWO OF YOUR ENGINEERS . . . WHO WORKING IN THE FIELD UNDER MOST DIFFICULT CONDITIONS MADE IT POSSIBLE FOR THE ARMY AIR FORCES TO TAKE THE OFFENSIVE WITH TELLING EFFECT AGAINST JAPANESE SHIPPING IN THE SOUTH AND SOUTHWEST PACIFIC AREAS UNDER CONDITIONS WHICH WOULD NORMALLY HAVE MADE SUCH OPERATIONS IMPOSSIBLE. . . .

These two were followed in 1944 by many other field engineers who worked with the China and India-based B-24 Squadrons, and with the big new B-29s of the XX Bomber Command in the China-Burma-India theatre and of the XXI Bomber Command in the Mariannas on Saipan, Tinian and Guam. Of these men, and of many other Western Electric field engineers doing similar work, Major-General O. P. Echols wrote to President Stoll, "The Army

Air Forces regard these men as an indispensable element in the All-American team of fliers."

A MOST EFFECTIVE WAY of showing the field engineer at work would be by montage movie photography.

improve training for jungle combat.

A field engineer on board the battleship INDIANA at an advance base in the Pacific teamed up with the ship's boatswain and, by working out an ingenious rigging system for replacing a faulty Mark 8 antenna

IT SERVED over Bikini. A Western Electric field engineer is making final adjustments on the radar "scope" camera aboard a B-29 which took part in the atomic-bomb test on June 30

While one field engineer was improving the pressurizing system of high-altitude bombing radar equipment in India, another was on leave with a National Defense Research Committee project down in Panama recording authentic jungle sounds to which weighed about one ton and was mounted high up on its upper works, they saved the ship a long trip to an Australian port. Incidentally, their success won $10,000 for their supporters among the crew, who had wagered enthusiastically on whether

such an exchange could be effected without resort to the large navy-yard cranes customarily used for such a heavy job.

At about the same time, one of this engineer's colleagues, in association with naval personnel, conceived a rearrangement of one of the fire control radar systems which greatly improved distribution of the target information for gunnery purposes.

One field engineer, under front-line conditions on Okinawa, used a piece of gas mask hose to conduct warm air from the magnetron of a search radar equipment to the transmission line, in which moisture condensation had been causing arcing trouble.

Two other field engineers on that disputed island were assigned to work with one of the Navy's most super-secret weapons, the radar controlled flying bomb, known as the Bat. In the words of a rear admiral, they showed a "willingness to tackle all jobs on all types and models of electronic equipment." They actually tackled 56 such jobs in their first 72 hours on Okinawa.

Letters of commendation and appreciation numbering several hundred have reached the Western Electric Company, during the war and since, from many Commands, expressing their satisfaction with and congratulations upon the efforts of Western Electric field engineers assigned to assist them. Included are commendations from the Royal Navy, the Royal Air Force, the British Air Commission, and the Office of Scientific Research and Development.

All the subject-matter worked on by the F. E. F. represented military secrets, most of them highly classified. The field engineer carried a constant burden of knowledge of great value to the enemy, which it was his duty to protect unremittingly.

In late 1944, two field engineers accompanied the first radio-link communication equipment sent to France. This very-high-frequency apparatus, basically the same sort of equipment as that recently placed in service on the West Coast to connect with Catalina and now being installed between the Massachusetts mainland and Nantucket Island, was used for communication between the 12th Army Group Headquarters and the 15th Army in Europe.

ONE OF THE cardinal points about radar was that it didn't work by decree. It took a lot of doing. When asked what he considered his assignment to mean, the Western Electric field engineer usually replied, "to go out there and make the radar work." He was by no means alone in this effort; but it is acknowledged that he was instrumental in creating faith in this new, versatile, and critically indispensable equipment.

These men did not get back home without having heard some angry shooting and having undergone a few hardships. "Hardships" is a calculated understatement for air raids, buzz bombings, mortar fire, sniping, torpedoes, plane crashes, bad food,

and spider bites—not to mention occasional climatic inroads on health.

One field engineer (from the Michigan Bell company) logged 193,775 miles in the course of a scant year on a Navy assignment. He covered 6,000 miles by submarine and spent 816 hours in air travel. During his first 24 hours on an island naval base, he led a rather precarious existence: 1). The plane in which he arrived made a belly landing. 2). He then was assigned to a vessel scheduled to sail that afternoon, but was prevented from boarding her by the merest chance—and she was never heard from again. 3). That night he left his tent two minutes ahead of the bomb that demolished it.

Three Western Electric field engineers lost their lives in the line of duty—all in accidents involving airplanes. The first death, at Marietta, Georgia, in late 1943, occurred during the initial tests, in one of the first B-29 airplanes, of the high altitude bombing type radar which was to be used in China-based raids against Japan. The second engineer to lose his life died in September of 1944 with eight others aboard a B-24 plane that crashed as it came in to land at Alamogordo, New Mexico. Early in 1945 another field engineer was killed in the crash of a transport plane which had just taken off from Australia enroute to a Philippine port, where he was to supervise the installation of a new radar system in submarines.

Most field engineers were inclined, none-the-less, to take a rather lighthearted view of the hazards of their profession. Indeed some of these hazards had their comedy aspects—at least in retrospect. One man will always remember the predicament of an Army nurse who stepped off a transport plane at Bougainville just as the Japs began to bomb the airfield. The nurse and the field engineer by chance made for the same fox hole, where their number was increased seconds later by six husky and very naked Marines who had been in swimming.

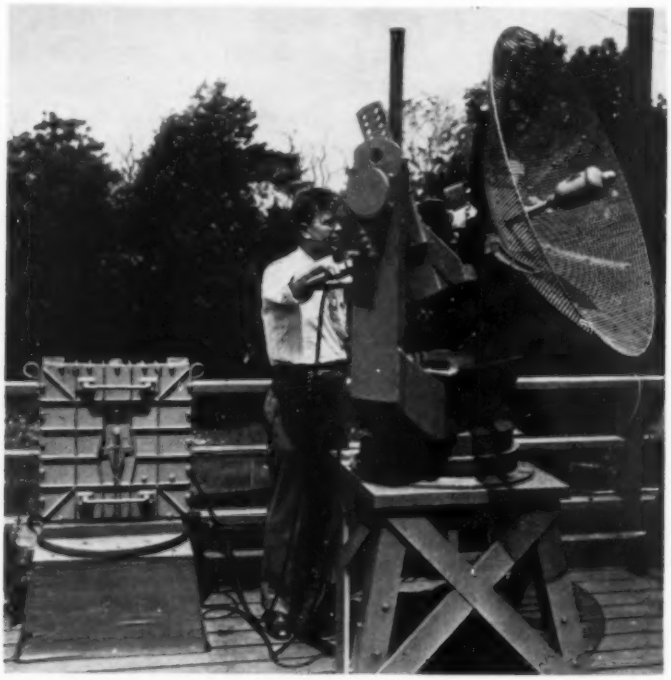
Recruiting and Training the F.E.F.

IT WAS NOT an easy task during the war years to find more than 600 engineers (counting a small turnover) who were willing and able to undertake this potentially dangerous but vital work. They had to be mature yet rugged and in A-1 health. They had to have technical skill and an imaginative engineering attitude. They not only had to satisfy the exacting employment requirements of Western Electric but to undergo a searching security investigation by the Army and Navy. It was necessary that they be adaptable in high degree yet thoroughly stable. Moreover, they could not be rough diamonds; the job called for men who were articulate and agreeable. On the whole, becoming a field engineer was hardly a matter of following the line of least resistance for these men, most of them family heads in their 30s and early 40s.

Into this rather high-voltage occupation came 132 men directly from

within the Bell System—22 per cent of the total group. Only the radio industry contributed a slightly larger number. There were, of course, men from the Bell Laboratories, from Long Lines, and from various parts of the Western itself; but the bulk of the Bell people came from 15 associated telephone companies.

The Bell System could not begin to supply the full requirements, however. The burden of this man-hunting job fell upon the "Bird-Dog" Department, as the Force's personnel organization became popularly known. Led by a former general plant employment supervisor of a mid-west telephone company who had himself been a field engineer, a group of ten former field engineers spent their time hunting out prospects in every section of the United States for the expansion of the Force. They found their recruits in 39 states, and even a handful from Canada and the British West Indies.



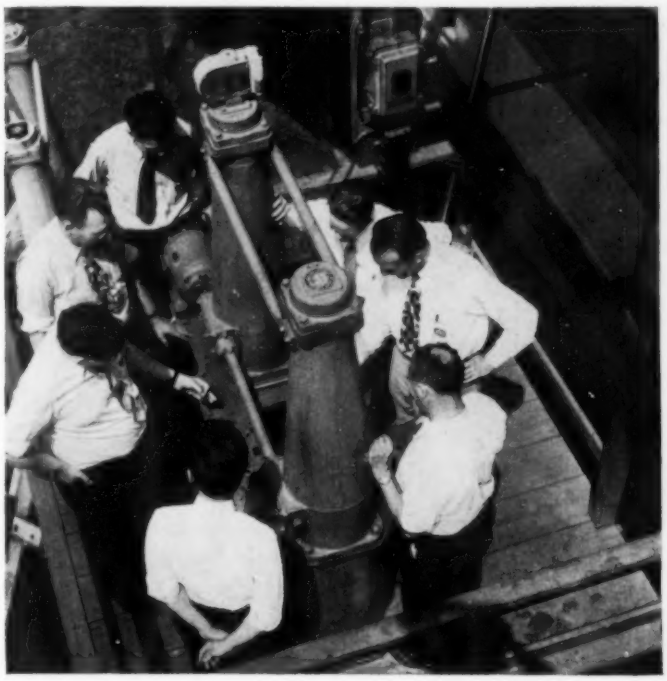
AT THE Whippany radio laboratory of Bell Laboratories, where Western Electric maintained one section of its F. E. F. training schools, a student engineer works with the antenna of a Naval radar

Some companies were better able than others to spare their valuable engineers and specialists during the manpower shortage. All of them, however, were glad to coöperate in every way possible with the Field Enginering Force search for additional field engineers to meet the increasing demands of the Army and Navy.

The roster saw virtually every

major American technical school, college and university represented in the membership. Naturally, electrical engineering degrees predominated although several other scientific degrees were to be found, including a number of Ph.Ds.

A MAJOR contribution to the development and management of the Force arose out of the experience of Electrical Research Products, Incorporated, in the sound motion picture equipment business, commencing in 1927. ERPI's extensive operating experience in the installation and servicing of sound equipment, in both the nation's picture-making studios and its theaters, provided a useful background. Several top supervisory positions were occupied by former ERPI men, all of whom had joined the Field Engineering Force in its early days. Still another pertinent and valuable asset was the experience, gained over many years, of the field engineering group maintained by Bell Telephone Laboratories for the assistance of the broadcasting industry in the installation and use of Western Electric radio transmitters.



AN F. E. F. instructor (left center) at the Whippany training school lectures on the features of the train and hoist mechanism to his class of sonar specialists

Every Western field engineer has in his possession a certificate which testifies that he has received some four to eight or more weeks of intensified F.E.F. training in the theory

Western Electric's field engineers were selected through nationwide recruiting from more than 200 vocations. To employ 606 engineers, 4,515 men were interviewed out of 14,100 considered in all. The cumulative growth was:

1941	*18*
1942	*134*
1943	*289*
1944	*486*
1945 (to V-J Day)	*606*

and operation of shipborne, airborne, or ground radar systems.

The Company's Radar Training School was the first step for every new field engineer. In 1941 and early 1942, it was conducted by Bell Laboratories engineers; but soon the fast-growing equipment development program took all of their time and the school passed to Field Engineering Force supervision and instructors, even though continuing to use space and facilities at Laboratories locations. The first Field Force head of the school was a university professor who, in 1942, had interrupted a lecture tour in upstate New York in order to become a field engineer.

MOST ENGINEERS came back periodically to the Schools of the Force for refresher courses, advanced courses, or courses on new equipment, and always after service in foreign theaters. Their training really never stopped, however, as they carried on their jobs in the domestic Navy Yards and at Army Airfields.

Here they wore no uniforms and had few thrilling adventures—unless it can be called "thrilling" to have a worker paint your hair with a spray gun or another burn the soles of your feet with an acetylene torch from the deck below. Here was a solid, if unspectacular, contribution of the Field Engineering Force in some 20 naval establishments from Casco Bay in Maine right around the coast line to Puget Sound in Washington, as well as at numerous fields of the Army and Navy Air Forces, airplane factories, and AAF modification centers throughout the United States. While these were the principal military activities served in volume, the Force also assisted several other branches of the Army and Navy and O.S.R.D.

IT WAS NOT always so unspectacular, either. Our Navy needed its ships on the firing line; the "availability" of a ship was often cruelly short.

There was the case of the battleship MASSACHUSETTS, which arrived in Boston to prepare, as it later developed, for the bombardment at Casablanca. She wanted two fire control equipments replaced with radar of a later and improved design. But since she was under 12-hour sailing orders, no work could be started that might take longer than that to complete. Ordinarily, it took several days to complete a single installation of the new fire control equipment. The captain decided to replace, if possible, at least one of his old equipments. When this job, in the opinion of the Western Electric field engineer, was within 12 hours of completion (this point came at 2 A.M.), the captain gave orders to start the dismantling of the second outmoded equipment. Had the field engineer

FUTURE field engineers at a Western Electric radar training school in New York. The men shown here were studying Navy fire-control radar equipment

been wrong in his estimate of the time needed to complete the first new installation, and had the battleship then received her sailing orders, she would have had to sail for Casablanca with *no* radar fire control.

P.S.: It took 10 hours to finish the first installation—and the MASSACHUSETTS had her second new equipment operating, too, before she sailed.

THE "BIBLE" of the field engineer working far from his company headquarters, and possibly far even from any brother engineers, was his collection of engineering notes or "Equipment Bulletins." Because of the diversified and difficult nature of his responsibilities, the field engineer relied on their comprehensive coverage, in concise, accurate terms, of a great variety of apparatus, systems, and theory.

Containing circuit and assembly drawings as well as illustrations describing 67 different equipments and systems, they form a complete reference in miniature to the apparatus and its proper operation and maintenance, prepared with a special regard for the particular needs of the engineer in the field.

Throughout the war, these bulletins were kept up-to-the-minute, reflecting all changes and modifications in existing equipments immediately and keeping abreast of the initial appearances of new equipment and systems as they were introduced.

By early 1945, there were nearly 30 experienced field engineers assigned to the writing, editing, and

More than half of the working time of the Western Electric field engineers was occupied in the instruction of Armed Forces personnel detailed to radar duty.

STANDING in front of the jeep is one of the 18 Bell System engineers who worked on military communications in the European Theater as members of the Western Electric field engineering force

modifying of the technical bulletins and miscellaneous manuals which field engineers and Service personnel alike found invaluable in their work. Embracing 20,500 pages of a special small size compiled into neatly bound loose-leaf volumes, each from two to three inches thick, more than a score of these have been published for the guidance of the Field Engineering Force. Perhaps in no other respect was the experience of ERPI so strikingly apparent as in the conception and preparation of these bulletins, which served at once as authoritative instruction manuals and as reference works.

SOMEWHERE between the glamour and diversity of the overseas field engineering assignment and the steady basic work in domestic locations come the activities of the field test group.

The group was organized in 1942, at the suggestion of the Bell Laboratories. There were naturally some "bugs" in new radar systems which could not be anticipated in the design stages and which could be eliminated only by actual field testing. For this work, several of the most experienced field engineers were organized into a field test group; by 1945, 17 men were engaged in this work.

This story of a typical field test contribution should also provide a valid and accurate picture of what field engineering was all about:—

In February of 1944, one of these field engineers went down to Dam Neck, Virginia, to the Bureau of Ordnance Anti-Aircraft Training and Test Center. He was to participate in various tests involving new West-

ern Electric radar equipment for anti-aircraft fire control. The assignment was the beginning of an interesting chain of events.

To the operator of such a piece of radar equipment, the target plane appeared as a small bright dot on the fluorescent screen of the oscilloscope. His job was to keep the cross-hairs of the gun sight centered on that dot; in this position the gun should be properly trained on the target. And this was so when the plane was coming in directly towards the battery. However, when the plane turned and flew to one side or the other there was a somewhat irregular and disturbing phenomenon. The little dot on the screen was a fraction of a second slow to react and to simulate the plane's movement, *and it never did catch up.* The dot floated across the screen in a position actually some distance behind the real position of the plane. Thus, when the operator kept his cross-hairs on the dot, he still was not actually "on target."

This trouble was caused, it turned out, by a rather lengthy "time constant"—the steady interval of time which elapsed between the reception of a radar "echo" from the target and the conversion of this tiny pulse of energy into a visual signal. Radar energy travels with the speed of light—but to throw a meaningful signal on a fluorescent screen takes just a bit more time than that.

The field test man was able to suggest circuit changes on the spot—changes which reduced the "time constant" to only one-fifth of its former infinitesimal split-second length and brought the radar signal and the actual target virtually into conjunction. This circuit modification was then reported to the Bell Laboratories engineers, who incorporated it in their design for all subsequent radars of this type.

After conferences at New York, the engineer proceeded to Hawthorne to observe the first of these equipments in their final acceptance tests. From Hawthorne, he accompanied the first five systems to the Navy Yard at Mare Island, California, where he supervised their installation aboard four destroyers and a heavy cruiser. He then prepared a lengthy installation report which was submitted to Bell Laboratories and to Navy Ordnance Planning.

Now came two weeks of maneuvers and tests aboard the destroyer MAHAN. The field engineer assisted the Fire Control Officers in training their personnel on this new system. He assisted them to such good effect that the radar fire-control performance of the ship improved by 67 percent in this period, to the obvious satisfaction of the Squadron Commander and the ComDesPac Gunnery Officer, who were acting as observers.

A later report from the MAHAN stated that in 1,547 hours of radar operation, zero hours were lost due to failures.

THE SAGA of the part the F.E.F. played in the rehabilitation of telephone communications in France, Belgium and Germany from the time of the Normandy beachhead until well after V-E day—that is a field engineering contribution which cannot adequately be reported here. The eighteen engineers engaged in this program, most of them on loan from Bell Laboratories or from associated

telephone companies, exhibited courage and resourcefulness of high order in cutting over damaged and disrupted enemy communications to the uses of the Allied forces. Not the least remarkable part of their accomplishment was their coördination of American, English, French, and German telephone and carrier equipment into smoothly functioning systems.

The End of the Story

WITH THE ARRIVAL of V-J Day, some of the contractual services performed by the Field Engineering Force for the Army and Navy were terminated immediately. Right up until the week preceding total victory, Western Electric had been hiring and training field engineers to meet the ever-expanding demands from the armed forces. Then came the sudden reversal of direction and the necessity for reducing the enrollment drastically. Since then, the remaining activities have been tapered down to a small fraction of the going rate at the war's end—enough only upon a temporary basis to facilitate an orderly transition to peacetime operations.

One field engineer, a veteran of two overseas assignments with the American Air Forces, left on his third not long ago—this time to the Bikini Islands for radar work with the bombers on Operation Crossroads.

Three others from the Bureau of Ships branch, all specialists on naval fire-control radar, likewise were members of the joint Army and Navy task force which conducted the atom bomb tests.

Several of the former field engineers have transferred to other parts of the Western Electric Company, to the Bell Laboratories, or to Associated Companies, and are applying their war-won knowledge toward the achievement of peacetime projects, such as mobile telephone service, point-to-point communication, and various other pursuits.

But most of the Field Engineering Force technical staff have gone back to their families and friends in their home states and the occupations, generally speaking, from which they came. The telephone men have returned, with few exceptions, to their companies. The radio men have gone back to radio—some of them as chief broadcast engineers. The teachers have gone back to teach—with a lot of valuable practical experience to bolster their theory. A number of men have started their own engineering, radio, or other businesses.

Despite this scattering to the winds, these field engineers still feel the pride and satisfaction which was theirs as members of this effective Bell System war-time organization. They feel that, during the war, they made the contribution most in line with their training and abilities, and that their hard work and varied experiences will enable them to play fuller roles in American life and industry.